# OBJECT LESSONS
IN
# ELEMENTARY SCIENCE
FOR
STANDARDS I. II. & III.

*GARLICK*
*AND*
*DEXTER*

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# ELEMENTARY SCIENCE

FOR

## STANDARDS I. II. & III.

BY

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*SECOND EDITION*

LONGMANS, GREEN, AND CO.
39 PATERNOSTER ROW, LONDON
NEW YORK AND BOMBAY
1897

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26.4.94
8249

~~Edc 136~~
Ed 119

# PREFACE

THE following Lessons, all of which are selected from Circular 369, are an attempt to meet the requirements of the Education Department as laid down in that circular, and the suggestions there given mark a very distinct advance in this form of instruction.

A choice is offered to suit special aptitudes, predilections, or localities; but whatever choice is made, the children should be allowed to handle or watch the actual objects on which the lesson is being given. In this way only will they cultivate the habit of obtaining knowledge directly and at first hand. Class rambles and visits to museums, botanical or zoological gardens, will be advisable if the children are to see some of the objects, or to observe them in their natural surroundings. These visits and rambles will help to develop the faculty of observation, and to give that love of nature which is such a happy possession for all time.

Attention has been paid to mental training rather than to imparting information, and for this purpose an attempt has been made to arrange the lessons in an orderly manner, so as to enable the children to make their own inferences from their own observations, or from the experiments submitted to them. Where the lesson does not lend itself so readily to this method of treatment, efforts have been made to use it as a special training in observation. This is the case in some of the lessons on plants, where the names used and the information given are subsidiary to the observation demanded.

The teacher is advised to sketch freely in the lessons, and for this purpose a large number of illustrations have been added, most of which lend themselves to Black-board work. Where suitable, the sketches should afterwards be made by the children in a subsequent drawing lesson.

All answers should not only be accurate in description, but should be given in complete sentences. A good training for this would be to follow each lesson, within a reasonable period, by a composition lesson on the object.

We have to express our obligation and gratitude to Mr. J. A. BUTTERFIELD, B.Sc., and to Mr. J. S. DEXTER, B.Sc., for their kindness in reading through the proofs.

A. H. G.
T. F. G. D.

[COPY.]

EDUCATION DEPARTMENT.

*Circular to H.M. Inspectors.* Circular 369.

## Object Teaching.

Education Department, Whitehall, London,
*25th June*, 1895.

SIR,

It has been observed that in Schools in which Object Teaching has been introduced with most success the teachers have carefully distinguished between two kinds of instruction which in other schools are not seldom confused. These two kinds of instruction are—(1) observation of the Object itself, and (2) giving information about the Object. This distinction is of importance, because the scope and method of the lesson differ according to its nature. Object teaching leads the scholar to acquire knowledge by observation and experiment; and no instruction is properly so-called unless an Object is presented to the learner so that the addition to his knowledge may be made through the senses.

Junior teachers have not unfrequently given lessons before H.M. Inspectors which were wrongly described as Object Lessons because in dealing with the topic selected no suitable appeal was made to the eye of the scholar. A lesson, for example, on the elephant to children in village schools, who have no opportunity of visiting either Museums or Zoological Gardens, may convey information and store the memory with interesting facts, but it does not cultivate the habit of obtaining knowledge directly and at first-hand, or develop the faculty of observation. However well the lesson may be illustrated by diagrams, pictures, models, or lantern slides, if the children have no opportunity of handling or watching the actual object which is being dealt with, the teacher will be giving an Information Lesson rather than an Object Lesson. It should be always remembered that in Object Lessons the imparting of information is secondary to the cultivation of the faculty of observation.

Object Teaching should further be distinguished from Instruction in Natural Science. It is Elementary Science only in so far as it aids the child to observe some of the facts of nature upon which Natural Science is founded; but as it deals with such topics without formal arrangement, it differs widely from the systematic study of a particular science. The principles of scientific classification, the continuous study of one group of natural phenomena, the generalisation from facts and the search for natural laws, belong to a later stage of mental discipline, which will be much more effectual if it is being based upon the preliminary training of the senses through sound Object Teaching. It is most important, therefore, that if, for example, Object Lessons are given on plant life, no attempt should be made to treat them as a continuous introduction to the study of Botany, or, if the lessons relate to animal life, to the study of Zoology. In Object Teaching the chief interest in the lesson should centre in the Object itself.

The following suggestions, which have been made by practical teachers, will be found useful :—

(1) The teacher should select only so many of the Objects set forth in the appended or other similar lists as can be dealt with in the year without overburdening the scholars. Habits of observation are better cultivated by the thorough examination of a few objects than by the superficial treatment of many.

(2) No Object should be chosen which the teacher cannot thoroughly illustrate either by the Object itself or by some adequate representation of the Object, or by both. All that is purely technical, whether in the mode of study or the language and terminology, should be carefully avoided.

(3) The children should be encouraged to bring with them to the lesson illustrative specimens which they have collected or borrowed from friends.

(4) The children should be encouraged to make simple drawings illustrative of their observations, wherever possible, and in certain cases to make simple records on square-ruled paper. Clay modelling and other manual occupations may be employed to test the accuracy of the impressions which the children form, and to fix them in their minds. Teachers also should frequently illustrate details of the lesson by blackboard drawings. Children who are jaded in five minutes by a lecture will be open-eyed and receptive for half-an-hour while the teacher draws as well as talks.

(5) Visits to Museums and other institutions of educational value are now recognised by the Code, and may advantageously be undertaken where possible in connection with the Object Teaching. Occasional class excursions out of school hours (or, if the instruction be in accordance with Art. 12 (*f*) of the Code, in school hours), under proper guidance, will enable teachers both to provide suitable Objects

and to confirm previous impressions. It should be borne in mind that Objects, when they are brought into the class-room, cannot be there studied under their ordinary conditions; and therefore it is important by a proper use of such expeditions to let the children see what part the Object plays in its usual surroundings.

(6) If the scholars are to learn intelligently from their Object Lessons, the first requisite is trained attention. The right method of securing this is to direct, in a conversational way, the attention of the children to the different parts of the Object in an orderly manner, and explain the relation of each part to the whole. After the analysis or study of separate detail, the Object should be again treated as a whole. It should not be left in fragments, but the division into parts should be followed when possible by the reconstruction of them into their original unity. Through such teaching the vague and indefinite impressions which children receive from Objects when they are first presented to them are gradually converted into clear mental pictures.

(7) The attempt to teach children to be accurate in observation cannot be separated from the need of making them accurate in description. After the children have been trained to observe a fact they should be practised in making a correct statement of it in a sentence of their own. This oral answering in complete sentences will lead to correct use of the English language, both in talking and writing, and will store the mind with a useful vocabulary. In the higher standards the children will be able to write brief weekly compositions in which they may express in a written form the ideas which they have acquired through oral instruction.

To sum up the main value of Object Teaching, there are three principal uses. The first and most important is to teach the children to observe, compare, and contrast; the second is to impart information; and the third is to reinforce the other two by making the results of them the basis for instruction in Language, Drawing, Number, Modelling, and other Handwork.

There are, however, other important uses of good Object Teaching. It makes the lives of the children more happy and interesting by opening up an easily accessible and attractive field for the exercise of brain, hand, and eye. It gives the children an opportunity of learning the simplest natural facts and directs their attention to external Objects, making their education less bookish. It further develops a love of nature and an interest in living things, and corrects the tendency which exists in many children to destructiveness and thoughtless unkindness to animals, and shows the ignorance and cruelty of such conduct. The value of the services which many animals render to man should be dwelt upon, and the importance of kindly treating them and preserving them should be pointed out. By these means, and in other ways, good Object Teaching may lay the foundation for the right direction of the activity and intelligence of the children throughout the whole school.

I have the honour to be,
SIR,
Your obedient Servant,
G. W. KEKEWICH.

# OBJECT LESSONS.

The following lessons deal with the ordinary phenomena of common life and with objects familiar to the children. The teacher's choice is not confined to these lists; other objects will be accepted subject to the approval of the Inspector. Any of the objects may be dealt with at the discretion of the teacher in more that one lesson, and although they have been grouped for convenience of reference, it is not intended to prescribe any specified number of them for a yearly course. With different treatment the same object may be adapted to more than one standard. Some teachers may prefer to deal with the same object in successive years, or to recur to it after a year's interval, expanding the study to suit the growing powers of the scholars. To meet the varying requirements of teachers it will be noticed that in some cases the names of the objects have been merely enumerated, while in other cases a few suggestions have been added as to the mode of treatment.

## I.—PLANT LIFE.

### (*a*) The study of plants as growing things.

Grow an onion in a bottle of water and note appearance of root and stem. Make a model in clay of the various stages of growth at short intervals.

Grow mustard seed on damp flannel and note stages of growth.

Notice a few curious roots.

The carrot. Cut off the top of one and grow it in a saucer of water. Contrast the root of a daisy (fibrous).

Roots which walk. Strawberry or strayberry.

Violet root.

Contrast root of Iris and Solomon's Seal in their modes of extension.

Stem. Count the rings in a trunk that has been felled. Rings, how produced; estimate age of tree; the record of wet or dry seasons.

Climbing stems. Ivy.

Train bindweed up a stick and note that it turns to the right. If you unwind it and force it the other way (to the left) note how it resumes its old direction again, holding the stick with one of its leaf stalks to get a purchase for the change.

Simple experiments to show effect of light on (1) leaves and (2) roots. Celery; blanching.

Leaves of deciduous trees contrasted with leaves of evergreens. Contrast leaves of holly, ivy, and box with leaves of oak, elm, and beech.

Note autumn tints. Collect and press leaves of various colours in autumn.

Buds. Leaf buds and flower buds.

Parts of a flower.

Fruits. Different kinds.

(*b*) **Blossoms, Fruit, Seeds, and Leaves.**

Parts of a flower.

Flowers of curious shape.

Pea blossom.

Insects and flowers.

Colours of flowers and insects.

Fruits. How seeds are scattered.

Shooting seeds.

Flying seeds.

Curious flowers, *e.g.*, primrose, compound flower (daisy); water lily.

Leaves. Shape, veining, arrangement.

Flowers as supplying (1) weather glass, (2) clock, (3) calendar.

Examine celery plant. Cut leaf stalks into thin sections to see how a plant is built up.

(*c*) **How plants are adapted to their surroundings.**

A bunch of spring flowers (according to time of year).

A bunch of summer flowers (according to time of year).

A bunch of autumn flowers (according to time of year).

Flowers and the soil. Bog plants. Riverside plants.

Plants that grow in running water.

Plants that grow in still water.

Meadow plants.

Plants of the heath and moor.

Plants of the hills. Plants of the wood. Plants of the sea-coast and salt marshes.

Sundew and flesh-eating plants.

Ferns.

The spores of ferns.

Grow some spores in a pan under glass and watch growth and development of a fern. Contrast with growth of mustard from seed.

Mosses.

Lichens.

Fungi.

Simple experiments in manuring plants.

How plants help or hinder each other's growth.

Parasites. Mistletoe.

Plants which help or injure man.

## II.—ANIMAL LIFE.

(*a*) The Cat (compare with Dog).—Eyes, rough dry tongue, soft pads and sharp claws, teeth, method of holding prey, drinking, covering of fur, whiskers, tail.

The Cow (compare with Sheep and Goat).—How she takes her food, teeth, chewing, milk (cheese and butter), tail, hoofs, covering, ears, horns, nose.

The Horse (compare with Donkey).—Covering, teeth, hoofs, tail, mane.

The Rabbit (compare with Hare).—Teeth, legs, feet, claws, covering, tail, whiskers, ears, eyes.

The Mouse (compare with Rat and Water Rat).—Teeth, paws, tail, whiskers, eyes, ears.

A Fish.—How fitted to live in water, weight, shape, covering, temperature, movements.

A Plaice (compare with Herring).—Flat, eyes on one side of head, gills, movements.

Animals which sleep in winter.—Examples: Squirrel, dormouse, common snake, frog, toad, snail, slug. Preparation made for sleep.

(*b*) Mole. — Shape, snout, teeth, paws, claws, eyes, ears, fur, food.

Hedgehog. — Covering of spines, how it rolls itself into a ball and why, head, teeth, food.

Common Snake (compare with Viper).—Shape, covering, teeth, how it moves, how it swallows its prey.

Frog (compare with Toad and Newt).—Movement, capture of prey, breathing, winter quarters.

Garden Snail (compare with Slug).—Shell, mantle, head, horns, eyes, food, preparation for winter sleep.

Earth Worm.—Shape, rings, locomotion, food, usefulness.

Spider (contrast with Bee).—Shape, segments, legs, eyes, jaws, spinnerets, web, breathing organs.

(*c*) Paws and Claws and their uses.—Cat, dog, rabbit, mouse, mole, frog.

Tails and their uses.—Horse, cow, donkey, dog, cat, monkeys, harvest mouse.

Tongues and their uses.—Cat, dog, cow, woodpecker, frog.

Teeth and their uses.—Man, cat, cow, horse, rabbit, snake, fangs of poisonous snakes.

Hair, Fur, Wool, and their uses.—Cat, mole, dog, sheep, fox.

Beaks of Birds and their uses.—Duck, fowl, parrot, sparrow, goat-sucker, heron.

Feet of Birds and their uses.—Duck, fowl, swift, owl, etc.

Insects.—Examples: bee, beetle, butterfly, cockroach, silkworm. Insect development, legs, wings, segments, mouth, breathing apparatus, ovipositors.

## III.—THE SKY, THE AIR, THE SURFACE OF THE LAND, AND WATER.

(*a*) **The Sky.**—Sunrise, noon, and sunset. (Note the object over which the sun is seen to rise from month to month. Note sun's position at noon, and its varying height above horizon.)

Shadow. (Note by aid of a spike erect on a flat disc the varying length of the shadow at noon. Study the shadows of objects. Variation in sharpness and depth.)

Moon. (Note the changes. Draw the shape from week to week.)

A few of the brightest constellations. (Make diagrams on square ruled paper from a study of the sky itself. Great Bear and Pole Star; Lyra and Vega; Cassiopeia.)

Planets. (Note any planet visible when the lesson is given. Mark its position on square ruled paper for a few weeks.)

Varying length of day and night.

(*b*) **The Air.** — Wind. Varying direction. (Note and keep record of the direction of the wind from day to day.)

Warmer and colder winds; rainy and dry winds.

Moisture in the air shown by seaweed; string (changing tension).

Wet cloth dries in the wind (water turns to vapour).

Vapour turns to water. (Breathing on slate. Clouds on hills. Evening mists.)

Clouds in the sky. Three chief kinds: 'heaps,' 'beds,' 'feathers.'

Rain. (Note size of drops. Raindrops on dust form little balls. Note effect of heavy rain in tearing up roads. Note the channels so made, and the arrangement of the sand and pebbles washed to a distance.)

Rainbow. (Note the succession of colours. Note position of sun behind observer and of the bow where the shower of rain is falling. Note that height of arch changes. When is it higher and when lower?)

Rainbow colours on shells, film of tar, etc. Feathers of birds.

Dew. (Note when formed. Cloudless weather. On what does it lie thickest?)

Hoar frost.

Snow. (Note size of flakes. Movement of flakes in the air as they fall. Snowdrift. Snow squeezed into ice.)

Hail. (Note when it falls. Examine hailstones. Is the hail accompanied by thunder?)

Thunder and lightning.

(*c*) **The Surface of the Land.**—Level or sloping. Simple way of measuring slope. Height of school and neighbouring hill tops above sea level.

Flow of water over the land. Neighbouring stream or streams. Water-partings.

The river basin in which the school is situated.

Construct a model fountain and make simple observations on the pressure of water. Milldam. A 'head' of water. Notion of falling water as a motor.

Soils. Clay, sand, slate, granite, chalk, quarries near school, gravel pits, clay pits, brick works. (Note how the rocks lie, in layers or in masses without structure.)

Stones in the brook, water-worn; pebbles on beach, rounded; pebbles in gravel pit often with sharp edges, perhaps iceborne.

Difference between sand and mud. Crumbling rocks. Effect of frost on damp rocks.

Caves by the sea formed by the waves; caves in land formed by rain dissolving limestone; stalactites. (A lesson for schools in limestone regions or near rocky coasts.)

Building stone, marble, slate, Bath stone, sandstone, etc.

In marble, note shells, etc. Note plants in coal.

Volcanic rocks. Lava, brimstone, pumice stone, basalt or whinstone. (According to the nature of the district.)

Rock salt; crystals of salt. Salt in sea water. Mineral in solution.

Hard and soft water. Rain water compared with streams from chalk or limestone; leavings after evaporation. Fur in kettles. Softening hard water.

(In certain districts) other minerals in solution, sulphur wells, iron springs, medicinal waters.

Mortar and cement. (Slake lime and make mortar; note the heat, etc.)

Surface soils. Crumbled rocks. Waterborne sand and mud. Vegetable mould and earth worms.

Vegetation and cultivation. Forest, moor and heath. Heathers.

Hedgerow trees, elms, ashes.

Trees of the forest, oak, beech, birch.

Evergreen trees, pines and firs.

Evergreen plants and shrubs, holly, ivy, box. Contrast evergreen and deciduous leaves. (Note changes at fall of leaf. Autumn tints. Press specimens.)

Riverside trees, willows, poplars, aspens.

Hill pastures and meadows. Turf on the downs and hay in the valleys.

Gardens and their contents. Garden fruits and wild fruits. Garden flowers and wild flowers.

(*d*) **Water.** — Standing water; ponds; pond life.

Springs and running water. Clear water looks shallower than it is. Simple experiments in illustration.

Study of flow of a stream. Where the flow is quicker (*a*) in the middle; (*b*) on one side, outer and inner bend. Where the bank is eaten away and where sand is spread out. Varying bottom; deep pools, shallows, sand banks. Confluence of tributary. Delta. Measure the speed at which the water flows.

Study of seashore. Rocky and sandy coasts. Soundings. The rise and fall of the tide. Currents. Drifting sand. Effect of frost on cliffs. Breakwaters. Layers of soil and rock exposed down the side of a cliff.

Measure with thermometer the temperature of (*a*) a spring; (*b*) a stream; (*c*) a pond; (*d*) the sea.

Ice. Study hardness, mode of fracture; splitting blocks with a needle. Does it sink or swim in water? Easy to make two surfaces of ice freeze together. Simple experiments with ice.

Watch and record behaviour of thermometer plunged in melting ice.

Melt some ice carefully to find out whether it takes up more or less room than the water into which it changes. (Force a mass of ice into a lump of clay and let it melt there.)

Freeze some water in a bottle and note bursting of bottle. Bursting of pipes.

Notes on expansion and contraction of substances illustrated by behaviour of water at different temperatures. Preliminary notion of thermometer.

Watch cold spring water being heated to boiling point in transparent glass vessel. Note bubbles of air given off, and as the water is heated bubbles of steam rising from below. Observe force of compressed steam. Preliminary notion of steam engine.

Dribble powdered alum into clear water. Hang thread in the solution and note the formation of crystal. Alum and other crystals.

Expose to the air crystals of (1) salt; (2) soda. Note change. What difference? What difference according to weather? Expose to the air crystals of saltpetre, and note result.

Dribble salt into clear water and note that it dissolves, quicker at first, then slower, at last no more is dissolved. Place a fresh egg in saturated solution and afterwards transfer it to clear water.

One liquid is denser than another. Compare water and mercury. Things which float in mercury and sink in water.

Upward pressure of water on bodies dropped into it. Why bodies sink or float. Why steel ships float. Why cork floats.

Simple experiments in displacement of water.

Simple experiments in pressure of water and pressure of air. Siphon. Squirt. Pump. Diving bell.

Distillation of water. Filtration.

Water; a combination of two gases, oxygen and hydrogen. Simple experiments.

## IV.—OBJECT LESSONS FOR TOWN SCHOOLS.

(*a*) The water we drink—how obtained.

Some of the simpler properties of water.

River (or canal)—according to circumstances.

Boats, barges, or ships, with which children are familiar—according to circumstances.

Other ships, *e.g.*, Atlantic liners.

Bricks—their size, shape, and manufacture; their size, &c., to be ascertained by children's measurements.

Bricklayer's work—arrangement of bricks in 14-inch wall and 9-inch wall, shown with real bricks or with small wooden ones; mortar, &c.

Coal—its simpler properties.

Coal—how obtained.

Coal—how transported and how used.

Coal gas; it may be made in presence of the children.

Gas works and gas pipes.

Petroleum—how obtained; its simpler properties and uses.

Lamps and their dangers.

Common stones used in building and road-making.

Road-making and paving.

Quarries and quarrymen.

Railways—general sketch.

Engines and carriages.

The work of railway men.

The park or public garden—general sketch.

The park or public garden—one or two of its more conspicuous trees.

The park or public garden—one or two of its more conspicuous plants.

Comparison between calico and flannel.

Cotton and its manufacture.

Lancashire and the cotton district; mills.

Sheep-clipping and rearing.

The West Riding of Yorkshire; factories, &c.

(*b*) Cart-horse.

Donkey.

Sparrow.

Rat or mouse.

Cat.

Plants grown in schoolroom (acorn in glass of water).

Plants grown in schoolroom (mustard and cress).

Plants grown in schoolroom (hyacinth in water or pot).

Plants grown in schoolroom (a fern).

Costermonger, and what he sells.

Some common fruits sold in streets or shops, *e.g.*, pears and apples.

Some common fruits sold in streets or shops, *e.g.*, strawberries.

Some common fruits sold in streets or shops, *e.g.*, oranges.

Some common fruits sold in streets or shops, *e.g.*, cocoanuts.

Things seen in grocer's window, *e.g.*, tea.

Things seen in grocer's window, *e.g.*, sugar.

Things seen in grocer's window, *e.g.*, coffee.

Things seen in grocer's window, *e.g.*, currants and raisins.

The baker and his work.

The milkman.

The addressing and posting of a letter.

The postman and Post Office.

The sweep and his work.

Dangers from fire and how they may be avoided.

The fireman and fire-engines.

'Bus or tram drives.

The policeman.

## V.—OBJECT LESSONS FOR COUNTRY SCHOOLS.

(*a*) The farmyard. Its buildings and their contents. Animals kept on a farm and their uses. Necessity of cleanliness, kindness, and suitable food.

The dairy and its contents. Butter and cheese making.

Bees. Bee-keeping.

Spring. Spring flowers. Work in the fields in spring. The cuckoo and swallow. Record date of arrival.

Summer. Different kinds of leaves and fruit. Work in the fields in summer.

Autumn. Work in the fields.

A mill and the work of a miller.

Winter. Frost. Ice. Snow.

Birds. Singing birds, as the thrush and nightingale. Birds of prey, as the hawk. Swimming and wading birds, as the duck and heron.

Wild animals. The fox, hare, and rabbit.

Minerals. A mine. Three useful minerals.

The lessons on the seasons should correspond with the actual seasons of the year, and the different operations explained should be taken while each is in progress.

Leaves of trees may be dried by simply placing them between sheets of paper and pressing them. Their shapes may be used for the children to draw round on paper, which can afterwards be pricked and then sewn round.

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| Springtime. | (*b*) The waking of Nature.<br>The lengthening daylight in the morning and evening, the coming warm weather, birds singing, building their nests, laying their eggs, the trees and hedges changing, buds and leaves, the bloom on fruit trees. |

The local wild flowers of spring. The daisy, primrose, bluebell.

Summer time.

The local wild flowers of summer.

Autumn.

The local wild flowers of autumn.

Winter. The repose of Nature.

The land. Woodland, meadowland, ploughland, moorland.

The sky.

A bird—covering, wings, beak, feet; motion; nests, eggs, food.

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|---|---|
| Local Birds. | Thrush or blackbird.<br>Lark.<br>Robin.<br>Rooks. |

Birds which come for the summer.

Birds which come for the winter.

Local wild animals.
  - Rabbit.
  - Hare.
  - Fox.
  - Hedgehog.

Animals on a farm.

Our village.

The carrier's cart.

The cottage garden.

The stream or river, its banks, the birds and animals that live near it.

A fish.

A plant.

(*c*) The garden in spring.

The farm in spring.

The garden in summer.

The farm in summer.

The garden in autumn.

The farm in autumn.

The garden in winter.

The farm in winter.

The weather and wind.

The soil; sunshine, air, rain, frost, manure.

The farmer's tools. The plough, drill, reaping machine.

The crops; grass, corn, root-crops. Wheat.

The potato.

The oak tree.

The elm tree.

The apple tree.

Evergreen trees.

An insect.

The spider and his web.

The butterfly; colours, beauty, history.

Bees.

The farmer's pests.

The farmer's friends.

A pond.

A frog.

A ramble in a wood and what may be seen there.

The railway.

Market-day in the neighbouring town.

A newspaper.

## VI.—OBJECT LESSONS IN THE SCIENCE OF COMMON THINGS.

(*a*) Water.—How carried, jugs, bottles, barrels, spouts, funnels. Wells. Things that float, things that sink.

Solids.—Hard and soft, in the room and in clothing. Files. Hammer and nails. Buttons.

Powders.—Flour.

Pastes.—Paste, clay, putty.

Things porous.—Bread, sponge.

Things that melt.—Butter, tallow, sealing-wax. Ice, snow.

Water.—Drying clothes, breathing on slates, frost on the pane. The boiling of the kettle. The pot boiling over.

Things that dissolve.—Sugar, salt.

Air. — Bubbles, pouring water through funnel into empty bottle. A burning candle. Fans, blowing feathers. Paper windmills.

Forms of Strength.—The floor, joists and boards. Wooden bridges. Steps and stairs.

Things that stretch.—Elastic bands.

Things that bend.—Bow and arrows. Cord, ropes.

Machines.—Tops. Roller for pastry, for garden. Perambulator.

Movements.—Walking running, leaping, creeping, crawling.

Musical toys.—Harmonicon. Bell.

(*b*) Water.—Pipes, taps, the fountain. Canals. Rafts, boats, anchors.

Solids.—Teeth, nails and claws. Sand-paper. Pins, needles, awl, gimlet. Hook and eye.

Powders.—Chalk, pencil.

Pastes.—Mud in streets, brick-making.

Things porous.—Brick, chalk, springs of water.

Things that melt.—Candle-making. Icicles.

Water.—Manufacture of salt from brine. Rain-drops, hail, spray, water-dust, the cloud.

Things that dissolve.—The manufacture of sugar

Air. — The chimney, draughts. Waves and breakers. Winged seeds. Shuttlecock, arrow and kite.

Forms of strength.—The ceiling. The arch. Ladders.

Things that stretch.—A football.

Things that bend.—Cart springs. Paper clips. Spider's web.

Machines.—Hoop, fly-wheel of sewing machine. Mangle. Waggon. Bicycle.

Movements.—Swimming.

Musical Toys.—Musical box. Drum.

(*c*) Water.—Siphon, pump. Oil, cream.

Solids.—Hinges, tires, and axles. The grindstone. Screws and screwdrivers.

Powders.—Black lead.

Pastes.—Pottery.

Things porous.—Blotting paper, towels, wicks, earth.

Things that melt.—Lead, iron.

Water.—Salt lakes. Distillation of water. Clouds and rain.

Things that dissolve.—Crystals, hard water, varnishes.

Air.—The pop-gun, the fire-engine. Winds. A sailing ship.

Forms of strength.—The roof. Railway bridges. Cranes.

Things that bend.—Clock spring. Chains.

Machines.—The loom. Threshing machine. Rolling iron rails. Coining.

Movements.—Flying.

Musical Toys.—Tin whistle. Sounds from stretched cord.

## VII.—MEASURING, WEIGHING, AND TESTING.

A two-foot rule.

Measurements of length—first by eye, then with rule.
Easy measurements of a square—first by eye, then with rule.
} Measurements in inches only.

Easy measurements of rectangles.

The wire-gauge.

Callipers.

Scales and weights.

Weighing of common objects—first by hand, then with scales; weight in ounces only.

Weighing letters.

Plumb-line.

Spirit level.

Steam—observations on boiling water; condensation of steam, &c.

Mercury—weight of; *cf.* drop of mercury and drop of water; effect of heat on mercury.

Alcohol—effect of heat on it; its evaporation.

Thermometer—its manufacture.

Thermometer—uses; readings in ice, in boiling water, under the tongue, in schoolroom.

A candle—its composition. The wick.

Candle under bell-jar over water; candle in narrow-necked bottle.

Chalk—where found; its origin.

Chalk—its treatment with acid.

Chalk—its reduction to quicklime with blow-pipe; lime-water.

Sugar heated in test-tube; wood heated in test-tube.

Sulphur heated in test-tube; lead heated in test-tube.

Magnet and iron filings.

The compass.

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# STANDARD I

## LOAF SUGAR AND CHALK.

**Things required.**—*Piece of sugar and chalk for each child; tumbler, water, spoon, colour card.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Tell children to look at specimen and note colour. | Both are like the colour marked white on card. | **Loaf Sugar and Chalk are white.** |
| 2. (*a*) Let children taste each.<br>(*b*) Try to write with each on B.B. | One tastes sweet, the other has no taste.<br>One will not write on B.B., other will. | **The one that tastes sweet is Sugar; the one that writes on B.B. is Chalk.** |
| 3. Let children feel each. | One feels rough, other smooth. | **Sugar feels rough; Chalk feels smooth.** |
| 4. (*a*) Tell children to break off corner of piece of sugar, and gently crush piece broken off. Examine powder.<br>(*b*) Repeat with chalk. | Sugar easily broken up into sparkling grains.<br>Chalk easily broken up into small non-sparkling grains. | **Sugar and Chalk are both easily broken. Sugar powder sparkles; Chalk powder does not.** |
| 5. (*a*) Take a spoonful of powdered sugar, put into tumbler partly filled with water; stir.<br>(*b*) Let several children taste the water. | Sugar disappears.<br>Water tastes sweet. | **We cannot see the Sugar in the water, yet we are sure it is there.** |
| 6. Make a strong solution, let child taste a drop. | Even a drop tastes sweet. | **The Sugar has spread itself all through the water.** [Teach that the Sugar has dissolved in the water; do not use the term melt.] |
| 7. Put powdered chalk into water; stir. | Chalk does not disappear. | **Chalk will not dissolve in water.** |

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B.B. SKETCH.

| **Sugar.** | **Chalk.** |
|---|---|
| **White** | **White.** |
| **Rough.** | **Smooth.** |
| **Breaks easily.** | **Breaks easily.** |
| **Dissolves.** | **Does not dissolve.** |

Oral composition to follow.

## BRICK (FIRST LESSON).

**Things required.** – *Red and yellow bricks, colour card, cube, paper, knife, pieces of paper same size as sides of brick, rulers.*

| TEACHING HINTS | INFORMATION |
|---|---|
| 1. Show red brick; let child pick out corresponding colour on colour card. Repeat with yellow brick. | Bricks are red or yellow. |
| 2. Let children count sides; put number on each side as counted. Also count number of corners. | Brick has six sides, eight corners. |
| 3. Introduce cube; have sides and corners counted. | Cube has six sides, eight corners. |
| 4. Cut out piece of paper same size as side of cube. Superimpose on all sides to show equality. | Six sides of cube are same size. |
| 5. Cut out piece of paper same size as largest side of brick. Superimpose, and show that only one other side is same size. Repeat for other sides. | Of six sides of brick, two are large size, two middle size, two small size. |
| 6. Divide objects in room into brick- and cube-shaped. | |
| 7. Pass prepared pieces of paper and rulers round class. Let children (*a*) measure size of large paper with rulers; (*b*) draw oblong on slates same size, following directions of teacher on B.B. | |

At next Drawing Lesson repeat with middle- and small-sized pieces of paper.

B.B. SKETCH.

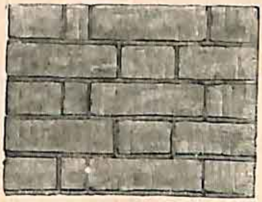
**Brick.**

**Red or Yellow.**
**Six sides, eight corners.**
**Sides are three different sizes.**

Oral composition to follow.

## BRICK (SECOND LESSON).

**Things required.**—*Bricks, block of wood same size as brick, sponge, water in pail, piece of iron, red ink, lump sugar, saucer.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Let child hold brick in hand, then block of wood, and compare weight.<br>(*b*) Put each into water.<br>Repeat with iron and sponge. | It is more tiring to hold brick than wood. Brick (and iron) sink; wood (and sponge) float. | **Brick (like iron) is heavy; Wood (like sponge) is lighter than Brick.** |
| 2. (*a*) Stand brick on end in saucer of water.<br>(*b*) Stand dry sponge on end in saucer of water.<br>Examine first sponge, and afterwards brick, for holes.<br>(Refer to damp rising up walls.) | Water is sucked up into brick.<br>Water is sucked up into sponge. | **Brick (like sponge) sucks up water by means of holes.** |
| (*c*) Place lump sugar in a little red ink in saucer.<br>Try to find holes. | Sugar sucks up red ink. | **Sugar must have little holes, but we cannot see them.** |
| 3. Let children note arrangement of bricks in wall of schoolroom or take them to wall of playground; or, better still, take them to watch a bricklayer at work. Imitate the arrangement with bricks in schoolroom. Draw on B.B., and let children copy next Drawing Lesson. | <br>FIG. 1. | |

B.B. SKETCH.

**Brick.**

**Heavy.**

**Has holes, which suck up water.**

Oral composition to follow.

## CLAY (First Lesson).

**Things required.** – *A piece of moist clay (brown or white) and a piece of paper for each child; putty, dough, india-rubber, elastic, bladder, evaporating dish, spirit-lamp, stone, glass.*

| Observations and Experiments | Results | Inferences |
|---|---|---|
| 1. Ask children to look at pieces of clay, compare with colours on colour card. | Clay is like colours marked brown or white on colour card. | **Clay is brown or white.** |
| (*a*) Let children touch clay.<br>(*b*) Dry some clay in evaporating dish. | Clay feels wet.<br>Steam escapes. | **Clay is moist.**<br>**Moist clay contains water.** |
| 3. Let children push finger into clay, scratch with finger-nail. Contrast with stone. | Clay yields to finger, is scratched by nail. | **Clay is soft.** |
| 4. Let child drop clay on ground. Contrast by dropping glass on ground. | Clay is flattened, does not break. | **Clay is tough.** |
| 5. (*a*) Note flattened part of clay dropped on ground.<br>(*b*) Let children flatten their pieces of clay on all sides (by knocking on pieces of paper placed flat on desk) and make them into cubes, then into square prisms, then into spheres. Note shapes after removal of hands.<br>Draw shapes on B.B., and use for next Drawing Lesson.<br>(*c*) Repeat with putty, dough. | Clay easily made into cubes, &c. | **Things easily made into any shape and which keep shape after removal of hands—Clay, Putty. Dough.** |
| 6. Take elastic, india-rubber, bladder partly filled with air, make into various shapes; remove hand. | These things can be made into various shapes, but do not keep shape when hand is removed. | **Things that can be made into many shapes, but which do not keep shape after removal of hands — Elastic, India-rubber, Air Bladder.** |

### B.B. Sketch.

**Clay.**
**Brown, white.**
**Moist—with water.**
**Soft.**
**Keeps shape—like putty,**
**not like elastic.**

Oral composition to follow.

## CLAY (SECOND LESSON).

**Things required.**—*Moist clay, flower-pot, sand, dried clay, ashes.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Mould clay into shape of small basin, pour in water.<br>(*b*) Place layer of clay at bottom of flower-pot, pour in water.<br>(*c*) Repeat (*b*) with sand. | Water does not run through clay, but does run through sand. | **Clay holds water, sand does not.** |
| 2. (*a*) Show some clay that has been exposed to sunlight for a day or so. Examine.<br>(*b*) Produce specimen from 2 (*b*) last Lesson. Examine.<br>(*c*) Knead some of the dry clay with water. | Clay has become hard, cracked, and powdery.<br>Clay becomes moist and soft. | **Clay becomes hard when water leaves it.** |
| 3. Drop dry clay on ground. | Clay breaks. | **Dry Clay is different from moist clay.** |
| 4. Place dry clay in bottom of flower-pot, pour in water. | Water runs through. | **Dry Clay does not hold much water.** |
| 5. Mix clay with ashes; bake for a long time. On a subsequent occasion compare with brick. | The baked clay and ashes and the brick are rough, suck up water, &c. | **A Brick is a mixture of clay and ashes baked for a long time.** |

B.B. SKETCH.

| **Moist Clay.** | **Dry Clay.** |
|---|---|
| **Easily shaped.** | **Not easily shaped.** |
| **Not easily broken.** | **Easily broken.** |
| **Holds water.** | **Does not hold much water.** |

**A Brick is made of baked clay and ashes.**

Oral composition to follow.

## SAND.

**Things required.**—*Sand for each child; slates, water, coarse sandstone, tumbler, spoon, sugar, flower-pot containing sand through which water has been run several times, muddy water, small pail, colour card.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Draw attention to specimen, and compare colour with those on colour card. | Colour of sand most like that marked yellow on colour card. | **Sand is yellow.** (*The colour of the sand will vary somewhat with the locality*) |
| 2. Get children to spread out sand in thin layers over slates. Compare and contrast appearance with that of sugar. | Sand easily spread out into layer of small shining pieces. | **Sand, like powdered loaf sugar, is made up of shining grains.** |
| 3. Drop sand into water. | It sinks. | **Sand is heavier than water.** |
| 4. (*a*) Stir up water.<br>(*b*) Cease stirring. | Sand carried round.<br>Sand sinks to bottom. | **Moving water makes sand float.** |
| 5. Try to dissolve sand in water Dissolve sugar as contrast. | Sand does not disappear. | **Sand does not dissolve in water.** |
| 6. (*a*) Pour water into sand in flower-pot. Recall similar experiment with moist clay. | Water runs through. | **Sand does not hold water, but holds dirt.** |
| (*b*) Pour muddy water into flower-pot. | Water runs through clearer. | **Water can be made purer by running it through sand.** |
| 7. (*a*) Take moist sand and press as much as possible into small pail, invert pail, and turn sand out. | Sand becomes caked and hard. | **Sandstone is made up of grains of sand that have been pressed together.** |
| (*b*) Take piece of coarse sandstone, scrape it. Examine powder, compare with sand. | The sandstone powder is like sand. | [Extend inference to chalk.] |

### B.B. Sketch.

**Sand.**

**Yellow—made up of grains.**
**Does not dissolve.**
**Makes water purer.**
**Sandstone is pressed sand.**

Oral composition to follow.

## CANDLE (FIRST LESSON).

**Things required.**—*Candles, matches, fire, lamp, paper, slate, spoon, small sheet of glass, lard, butter.*

(*The Lesson should be given in a darkened room or a dark day should be chosen for the Lesson.*)

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Drop pin on floor; ask child to find it.<br>(*b*) Light candle to assist search. | Pin cannot be found.<br>Pin can now be found. | **Room is too dark.**<br>**Candle gives Light.** |
| 2. Blow out candle, light lamp, gas, &c. | Things can again be seen in room. | **Lamp, Gas, also give Light.** |
| 3. Re-light candle; ask child to put hand nearer and nearer candle flame. Repeat with fire. | Hand becomes warmer. | **Flame is hot. The nearer anything gets to flame, the hotter it becomes.** |
| 4. Bring piece of paper and match nearer and nearer candle and fire. | Paper and match catch fire. | **It is dangerous to go too near anything burning.** |
| 5. (*a*) Tilt burning candle held over slate.<br>(*b*) Note wax on slate. | Wax drops on slate.<br>Wax becomes hard. | **Heat melts wax.**<br>**Cold makes wax hard.** |
| 6. Scrape wax off slate, put in spoon over lamp. | Wax first becomes soft, then melts. | **Heat makes wax soft at first, then melts it.** |
| 7. Slowly melt lard or butter in a spoon. Ask what happens to butter when put on warm toast. | Lard, butter, become first soft, then melt. | **Lard, butter, when heated act like wax.** |
| 8. Make notch in candle about half-inch from top; light. At end of Lesson examine candle and wick. | Candle shorter; wick has wax in it. | **The melted wax goes into the wick, and is there burnt away.** |
| 9. Hold sheet of white paper flat over candle flame, or smoke glass in candle flame. Refer to soot in chimney, blackening of ceilings, &c. | Paper, glass, become covered with soot. | **Candle produces soot, so do fire, lamp, &c.** |

B.B. SKETCH.

**Candle.**

**Candle gives { light, heat, soot.**

**Heat melts wax.**
**Cold hardens wax.**

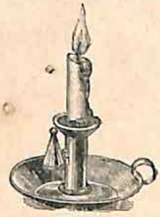
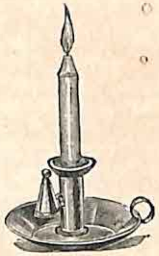


FIG. 2.

Oral composition should follow the Lesson.

## CANDLE (SECOND LESSON).

**Things required.**—*Candles, knife, cotton, spirit-lamp; cylindrical cardboard mould, open at one end, closed at other; glass beaker, wax, blacklead pencil.*

| TEACHING HINTS | INFORMATION |
|---|---|
| 1. Show candles; draw attention to parts. | Candle consists of :—<br>(1) Wax* or Tallow.<br>(2) Wick. |
| 2. Cut candle lengthwise; note wick. | Wick runs through middle of candle from one end to other. |
| 3. Take wick out of tallow candle, untwist cotton, show threads. Take several strands of ordinary cotton and twist into wick. | The wick is made of twisted cotton. |
| 4. Arouse children's attention by asking how wick gets inside candle. Take cardboard cylinder, attach twisted cotton to closed end. Melt wax in glass beaker over spirit-lamp. Hold twisted cotton so that it runs through centre of cylinder. Pour in wax; allow whole to cool. | Wax candles are made by pouring wax into mould through middle of which runs wick.<br>[Explain that candle moulds are made of metal, not cardboard.] |
| 5. While cooling is going on draw attention to shape of candle, contrast with round ruler and unsharpened pencil; sharpen pencil, compare with tapering end of candle. | Candle is same shape as sharpened blacklead pencil. |
| 6. Draw candle on B.B., and let children copy on slates. | <br>FIG. 3. |
| 7. Take cooled candle out of mould, light it, and show that it behaves like an ordinary candle. Recapitulate the main points of First Lesson on Candle. | |

### B.B. SKETCH.

**Candle.**

**1. Wax* or Tallow.**
**2. Wick (Cotton).**

**To make Candle.**

**1. Put wick down middle of mould.**
**2. Melt wax, pour into mould.**

Oral composition to follow.

---

* In nearly all candles the so-called wax is either stearin or paraffin, not beeswax.

## COAL (FIRST LESSON).

**Things required.**—*Piece of coal for each child; large lumps of coal, hammer, black wool, fire, tobacco-pipes, clay, sawdust, water, fire or Bunsen burner, tongs, white plate.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Ask children to compare colour of coal with colours on colour card.<br>(*b*) Compare with colour of black wool.<br>(*c*) Ask children to examine coal more carefully.<br>(*d*) Let children rub fingers on dull and bright sides of coal. | Coal is same colour as that on card marked black.<br>Wool is a dull black; coal is a bright black.<br>Some sides of the pieces of coal are a dull black. | Coal is a bright black in colour. Some sides of a piece of coal are a dull black; these dull black sides blacken the fingers most. |
| 2. Ask child to press finger into ball of wool and into piece of coal. | Finger enters wool easily; will not enter coal. | Coal is hard. |
| 3. (*a*) Ask child to lift lump of coal.<br>(*b*) Drop piece of coal into water. | Difficult to lift.<br>Coal sinks. | Coal is heavy. |
| 4. (*a*) Strike coal with hammer.<br>(*b*) Take large piece of coal, strike it *along* its greatest length.<br>(*c*) Strike another piece *across* its greatest length. | Coal breaks.<br>Splits easily into layers.<br>Does not split so easily, and then only into irregular lumps. | Coal is brittle.<br>A piece of coal is made up of a number of flat layers. |
| 5. (*a*) Put piece of coal on fire, or hold with tongs in Bunsen flame.<br>(*b*) Repeat with wood. | Coal gives out brown 'smoke,' takes fire, cracks, leaves a white ash.<br>Same results. | Coal and wood burn easily. |
| 6. (*a*) Put some powdered coal into tobacco-pipe, cover top with layer of clay, heat, apply plate to issuing 'smoke,' ignite 'smoke.'<br>(*b*) Repeat last experiment, using sawdust instead of coal. | Cloud of brown 'smoke' issues, which deposits a sticky, black mass on plate; smoke burns.<br>Same results. | When coal and wood are made hot they give off smoke and a black, sticky stuff.<br>Coal is something like wood. |

### B.B. SKETCH.

**Coal.**
**Black, hard, heavy.**
**Burns—like wood.**

Oral composition to follow.

## COAL (SECOND LESSON).

**Things required.**—*Pieces of shale from coal measures with imprints of leaves, &c.; water, stone, slate, tar, tobacco-pipe, clay, coal, fire or Bunsen burner, brown-paper, coke.*

**Introduction.**—*Recapitulate last Lesson, dealing especially with the reasons for saying coal is like wood.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Pass round piece of shale showing impression of leaves, &c.; explain that shale was found near coal. | See figs. 4, 5, 6, 7. | **Coal is made up of the remains of plants and trees.** |
| (*b*) Show picture of tree root standing in 'under-clay.' | See fig. 8. | |
| 2. (*a*) Scrape shale, let powder fall into water. | Water becomes muddy. | **Shale was once mud, and was made under water.** |
| (*b*) Examine shale more closely. Compare with coal. (See last Lesson 4 (*b*).) | Shale and coal made up of layers. | **Coal was probably made under water.** |
| 3. Compare coal with stone, slate, or any other mineral which the children know is obtained from the earth. | Coal is like them in being hard, heavy, &c. | **Coal comes out of the earth.** |
| 4. (*a*) Repeat Experiment 6 (*a*) last Lesson, compare the black mass with tar. | It is black, sticky, and has smell of tar. | **Coal when heated yields tar.** |
| (*b*) Compare 'smoke' from pipe with smoke from brown-paper by trying to light each. Compare with lighted gas. | 'Smoke' from pipe lights; smoke from brown paper will not. | **The proper name for what we see issuing from the pipe is not smoke, but gas. Coal when heated yields coal gas.** |
| (*c*) Break pipe, examine mass within. Compare with coke. | It is like coke. | **Coal when heated yields coke.** |

### B.B. SKETCH.

Coal.
Was once trees and plants.
Was made under water.
Is dug out of the earth.
Things made from coal—1. Gas.
2. Tar.
3. Coke.

An Information Lesson on a Coal Mine could well follow here, and also a Conversation Lesson on the uses of wood, coal, coke, and gas, as heating and lighting agents.

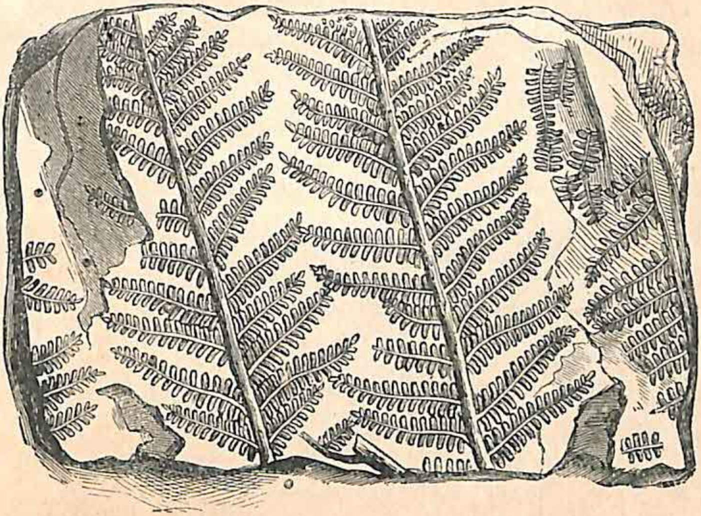


FIG. 4.—Tree fern from Coal Measures.

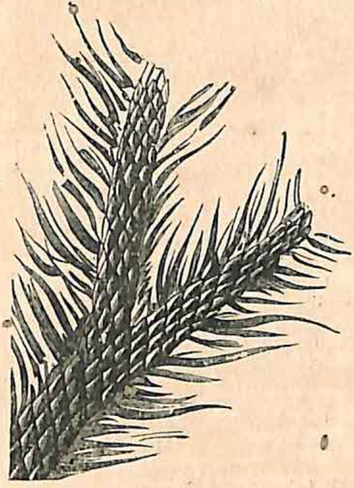


FIG. 5.—Branch of giant moss from Coal Measures.

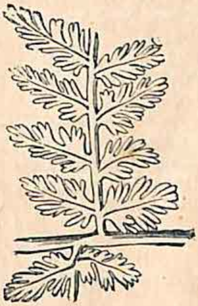


FIG. 6.—Fern from Coal Measures.

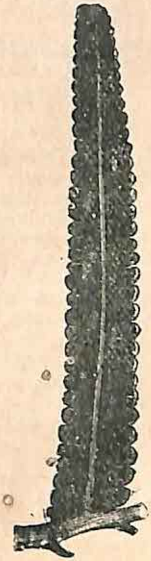


FIG. 7. Fern from Coal Measures.

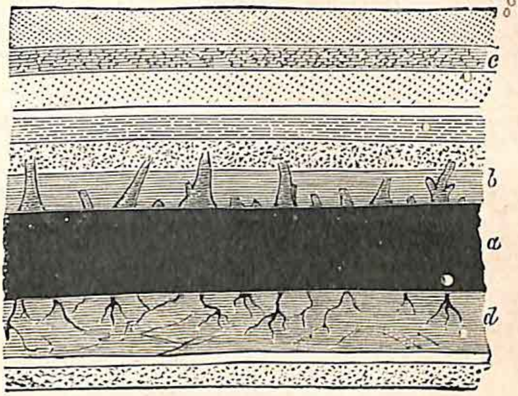


FIG. 8.—Section showing coal seam. *a*, coal seam; *d*, under-clay with roots; *b*, *c*, shale and sandstone forming roof, containing fossil stems, leaves, &c.

## LEAD.

**Things required.**—*Sheet lead, emery paper, a new shilling; pieces of lead, iron, and wood, the same size; water, knife, hammer; lead and iron piping of about same diameter; iron spoon, spirit-lamp.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Show sheet lead; contrast with bright silver shilling.<br>(*b*) Rub part of lead with emery cloth.<br>(*c*) Ask why mother wraps up silver teapot in cloth after cleaning it. | Lead looks dull.<br>Lead looks bright. | **Lead is bright in colour, but turns dull when air is allowed to get to it.** |
| 2. (*a*) Let child hold pieces of iron, lead, and wood, and state which is hardest to hold up.<br>(*b*) Drop each into water. | Lead is hardest to hold up.<br>Wood floats; lead and iron sink. | **Lead is heavy.** |
| 3. Let child try to cut lead and iron with knife. | Lead can be, iron cannot be cut. | **Lead is softer than iron.** |
| 4. Hammer out a piece of lead into a sheet; show some sheet lead. | Lead is easily made into a sheet. | **Lead is easily hammered out.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 5. Get child to try to bend lead and iron piping. | Lead bends; iron will not. | **Lead is easily bent.** |
| 6. Put a little lead in iron spoon; apply heat; tilt spoon. | Lead runs. | **Lead is easily melted.** |
| 7. (*a*) Try to write with piece of lead on paper. Compare with blacklead.<br>(*b*) Try to melt blacklead in spoon. | Lead marks on paper.<br>Blacklead does not melt. | **Blacklead is something like lead, but is not really lead.** |

### B.B. SKETCH.

**Lead.**

| | |
|---|---|
| **Bright.** | **Easily hammered out.** |
| **Heavy.** | **Easily bent.** |
| **Soft.** | **Easily melted.** |

Oral composition to follow.

## IRON.

**Things required.**—*Nails, hammer, poker; pieces of iron and wood of equal size; water; iron rod, and piece of glass tubing about same diameter; heavy weights; iron and lead tubing of about same diameter; fire, sheet iron, iron wire, piece of rusty iron, lead, iron spoon, magnet, penny, shilling, iron filings, sand.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Let child hold piece of iron and wood of same size.<br>(*b*) Drop each into water. | Iron harder to hold up than wood.<br>Iron sinks; wood floats. | **Iron is heavy.** |
| 2. (*a*) Let child scratch wood with iron nail.<br>(*b*) Drive nail into piece of wood; pull nail out, and examine. | Wood easily scratched.<br>Nail not altered, but hole has been made in wood. | **Iron is hard.** |
| 3. Rest iron and glass rods on two supports. Hang heavy weights on parts of rod between the two supports. | Glass rod breaks; iron rod does not break. | **Iron is strong.** |
| 4. (*a*) Get child to try to bend iron and lead tubing.<br>(*b*) Put poker in fire till end is red-hot; press hot poker sideways on hearth. | Lead tubing bends; iron tubing does not bend.<br>Poker easily bent. | **Iron does not bend when cold, but bends when hot.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 5. (*a*) Get child to strike piece of iron wire with hammer.<br>(*b*) Make wire red hot; strike with hammer.<br>(*c*) Show specimens of sheet iron and iron wire. | No effect is produced on iron.<br>The iron wire is flattened. | **Iron can be hammered out when hot, but not when cold.**<br>**It can also be made into wire.** |
| 6. Melt lead in iron spoon. | Lead melts; spoon does not. | **Iron does not melt easily.** |
| 7. Show piece of iron that has been exposed to air for a long time. | Iron is covered with brown scales. | **Air rusts iron.** |
| 8. (*a*) Try to pick up nail, penny, shilling, lead, &c., with magnet.<br>(*b*) Separate iron filings from sand by means of magnet. | Magnet picks up only the iron. | **Iron is the only common thing a magnet will pick up.** |

**Iron.**

**Heavy, hard, strong.**

**When heated can be bent, and hammered out into sheets. It can also be drawn out into wire. Does not melt easily. Rusts in air. Is picked up by magnet.**

Oral composition to follow.

## WATER (FIRST LESSON).

**Things required.**—*Water, milk, treacle, oil; various shaped bottles, flasks, &c.; greasy slate, ink, vinegar, stone, wood, white paper, sugared water, vinegar.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Take flask full of water; tilt flask.<br>(*b*) Repeat with water, milk, treacle, oil, stone, wood. | Water runs out. | **Things that pour—water, milk, treacle, oil.**<br>**Things that do not pour—stone, wood.** |
| 2. Pour water into various shaped vessels. | Water fills up every part of vessels. | **Water easily changes its shape.** |
| 3. (*a*) Let water drip on slate; note shape of drops.<br>(*b*) Ask for shape of raindrops.<br>(*c*) Let water drip on greasy slate. | Water splits up into drops. | **Water is made up of a number of round drops.** |
| 4. (*a*) Draw attention to surface of water in vessels in (2). Tilt the vessels; note surface.<br>(*b*) Recall surface of water in pond.<br>[Show picture something like fig. 9.] | Top of water always flat. | **Water always has a flat top.** |

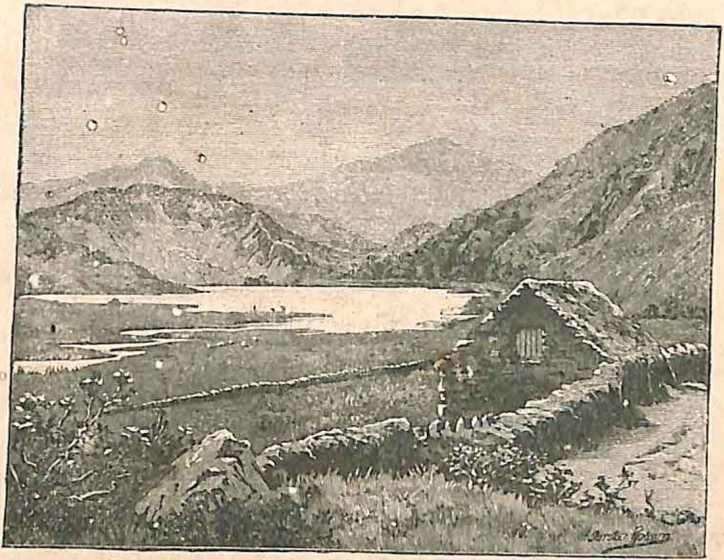


FIG. 9.—A lake lying among hills.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 5. Compare 'colour' of water with colours on colour card. Contrast especially with piece of white paper. | There is no colour on card like colour of water. | **Water has no colour.** |
| 6. Let child taste water; contrast with taste of sugared water and vinegar. | Water tastes neither sweet nor sour. | **Water has no taste.** |
| 7. Ask child to smell water; contrast with vinegar. | Vinegar 'smells'; water does not. | **Water has no smell.** |
| 8. Drop penny into a glass of water, then one into glass of milk; hold each up to light. | Penny can be seen in water, not in milk. | **Water lets light pass through it.** |

## B.B. SKETCH.

**Water.**

| | | | |
|---|---|---|---|
| **Pours** | **like milk.** | **Has no colour** | **not like milk.** |
| **Changes shape** | | **Has no taste** | |
| **Has flat top** | | **Lets light through** | |
| **Is made up of drops** | | | |

Oral composition to follow.

## WATER (SECOND LESSON).

**Things required.**—*Pieces of wood, cork, stone, iron, all the same size; toy boat, water; one can with hole in side, another with hole in bottom.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Place wood, cork, stone, iron, toy boat in water. | Wood and cork float; iron and stone sink. | **Some things float in water; others sink.** |
| 2. Ask child to hold wood, cork, stone, iron, and pick out the two heavy and the two light ones. | Wood and cork are light; iron and stone are heavy. | **Light things float in water; heavy things sink.** |
| 3. (*a*) Again float cork and wood in water, and note which sinks deeper into the water.<br>(*b*) Ask child to compare weights of cork and wood by holding them in hand. | The wood sinks deeper into the water than the cork.<br>The wood is heavier than the cork. | **Floating things are partly in and partly out of the water.**<br>**The lighter a thing is, the more of it floats out of the water.** |
| 4. Push cork down to bottom of water; note resistance; remove hand. | Cork returns to surface. | **Water presses upwards.** |
| 5. (*a*) Place heavy weight on hand of child's arm extended to full length.<br>(*b*) Repeat with stone, wood, cork, &c. | The heavy weight presses the hand downwards.<br>The stone, wood, &c., also press downwards, but not so much. | **Heavy things press downwards a good deal; light things press downwards only a little. Light things float because they press downwards with less force than water presses upwards.** |
| 6. Take can with small hole in bottom, cover with finger, fill with water, remove finger. | Water runs out. | **Water presses downwards.** |
| 7. Repeat with can with hole in side. | Water runs out (fig. 10). | **Water presses sideways.** |

### B.B. SKETCH.

**Things that float in water—Wood, cork—Light.**
**" " sink " " —Iron, stone—Heavy.**
**Water presses upwards**
**downwards } every way.**
**sideways**

Oral composition to follow.

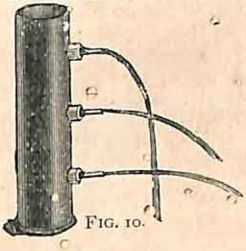


FIG. 10.

## WATER (THIRD LESSON).

**Things required.**—*Water, sugar, salt, chalk, sand, spirit-lamp, hot water, evaporating dish.*

**Introduction.**—*Recapitulate Lesson on Loaf Sugar and Chalk* (*p.* 1).

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Try to dissolve sugar, sand, salt, chalk, in water. | Sugar and salt dissolve in water; sand and chalk do not dissolve. | **Some things dissolve in water; others do not.** |
| 2. Add salt to cold water, at first plentifully, then more sparingly; stir; continue till no more salt dissolves. | Salt dissolves at first quickly in water, then more slowly, and by-and-by will not dissolve at all. | **Water can get so full of salt that it will not hold any more.** |
| 3. Get child to place finger in water [note that it is cold], apply spirit-lamp [note that water gets hotter]; note what becomes of salt at bottom. | Salt dissolves. | **Cold water that will not hold any more salt can be made to hold more by heating it.** |
| 4. *Fill* flask with water; apply heat. [Much time will be saved if the water put into the flask is already hot.]<br>Recall 'boiling over' of kettle. | Water runs over. | **Hot water takes up more room than cold. Hot water can hold more salt than cold, because it has more room in which to hold it.** |
| 5. Fill flask half full of water (preferably warm water); heat; note results. Compare sound made by water to singing of kettle. | Bubbles form, rise, and burst, at first some distance from surface, afterwards on the surface itself. (fig. 11). | **The singing of the kettle is caused by the bursting of the bubbles. When the bubbles rise to the top the water boils.** |
| 6. Place a little water in an evaporating dish; boil. | All the water changes into steam (fig. 12). | **Steam is a form of water.** |
| 7. Place a little of the salt water in dish; boil; let children taste residue. | Water changes into steam, salt is left behind. | **Salt can be got from salt water by boiling away the water.** |

B.B. SKETCH.

**Things that dissolve—Sugar, Salt.**
**Things that do not dissolve—Sand, Chalk.**
**Hot water dissolves more salt than cold water.**
**To get salt from salt water, boil away the water.**

The shape of the flask of water may be used as a Drawing Lesson.

Oral composition to follow.

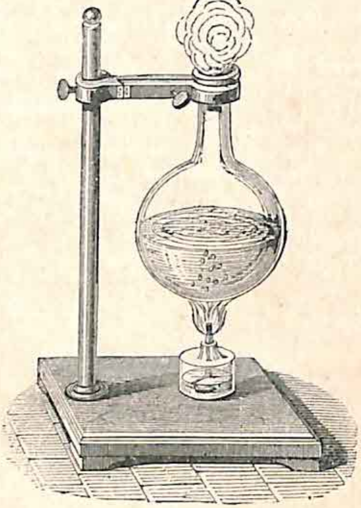


Fig. 11.[*]

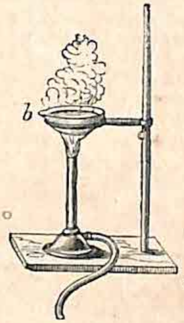


Fig. 12.

## AIR.

**Things required.**—*Water, bellows, paper, feathers, toy windmill, small sailing-boat; bottle with well-fitting cork, through which a funnel is inserted; light flask with tightly fitting india-rubber tube provided with a clamp; pair of light scales, stone.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Let child move hand in air (*cf.* moving hand in water).<br>(*b*) Blow bellows against hand. | Something seems to push against hand. | **Air can be felt.** |
| 2. Blow bellows against pieces of paper, feathers, toy windmill, model sailing-ship in water. | Paper, &c., move. | **Air moves things; air itself moves.** |

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[*] In this and similar experiments a piece of wire gauze or a sand-bath interposed between the flame and the flask will obviate the risk of fracture of the glass.

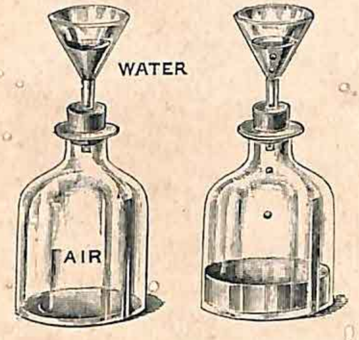
| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. (*a*) Pour water into funnel of specially prepared bottle.<br>(*b*) Shake bottle. | Water does not run through.<br>Water runs through (fig. 13). | **Air takes up room.** |
| 4. Weigh specially prepared flask (fig. 14), open clamp; suck air out of flask; close clamp, remove mouth; weigh again; or heat to drive out air. | Second weight is lighter than first. | **Air weighs something.** |
| 5. (*a*) Drop stone into glass full of water.<br>(*b*) Weigh stone. | Water runs over glass. | **Air is as much a thing as stone is, for:**<br>**(1) It takes up room.**<br>**(2) It weighs something.** |

## B.B. SKETCH.

Air.

**Can be felt.**
**Takes up room.**
**Weighs something.** } **Air is a thing.**

Oral composition to follow.



Before being shaken. After being shaken.

FIG. 13.

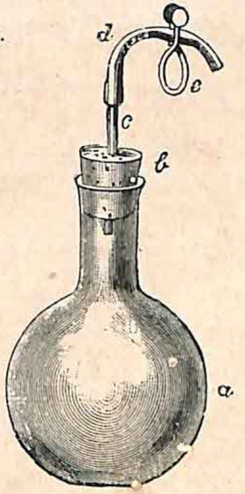


FIG. 14.—Apparatus for proving that air has weight. *a*, Glass flask; *b*, cork; *c*, glass tube; *d*, india-rubber tube; *e*, spring clip for closing *d*.

# PLANTS AS GROWING THINGS.

**Things required.**—*Specimens of plants illustrating the different stages of growth; other specimens of complete plants; specimen onions grown on the necks of bottles or German flasks. Other things as detailed in the Lesson. Copper sulphate solution.*

| OBSERVATIONS AND EXPERIMENTS | INFERENCES |
|---|---|

## WHAT IS A PLANT?

| OBSERVATIONS AND EXPERIMENTS | INFERENCES |
|---|---|
| 1. Show a living plant (in a flower-pot) and a dead plant. Contrast with a piece of chalk or any other mineral. | **Plants live and die; minerals do not.** |
| 2. Call attention to the different parts of a complete plant. *The parts differ in many ways.* Now show a piece of chalk; then break it up. *The parts are all alike.* | **The parts of a plant differ. The parts of a mineral do not differ.** |
| 3. Show a solution of copper sulphate a week before the Lesson, and let the class note the *growth* of the crystals. | **Things that have no life can grow bigger.** |
| 4. Call attention to the various specimen plants used for Lesson. | **Plants grow.** |
| 5. Call attention to the *curved* surfaces of *plants*; contrast with *flat* surfaces of *minerals*. | **The shape of plants and minerals differs.** |
| 6. Call attention to the method of growth in each case. | **Plants grow from within, and minerals by addition from without.** |

## THE PARTS OF A PLANT.

| OBSERVATIONS AND EXPERIMENTS | INFERENCES |
|---|---|
| 1. Show a complete flowering plant (in a flower-pot) to the children. Point out the parts—stem, leaves, roots, flowers, branches, buds, &c.—and have them learned from the specimen itself. | **Each part of the plant has its own name.** |
| 2. Then test with one or two other varying specimens. | |
| 3. Test further with the picture of a tree. | |

## PLANTS AS GROWING THINGS.

| OBSERVATIONS AND EXPERIMENTS | INFERENCES |
|---|---|
| 1. Show specimens of plants in various stages of growth, and ask class to note—<br>(*a*) Some are just above the soil.<br>(*b*) Some are well above the soil.<br>(*c*) Some are fully grown. | **Plants differ in their growth.** |

| OBSERVATIONS AND EXPERIMENTS | INFERENCES |
|---|---|
| 2. Question for these differences, and elicit (tell where necessary)—<br>(*a*) Some plants require longer than others to grow.<br>(*b*) Some may have been planted later than others.<br>(*c*) Some may have had more care shown them than others—better soil, better light, &c. | **Plants are all the better for being carefully looked after.** |
| 3. Grow an onion in a bottle of water, and note the stages of its growth (fig. 15).<br>(*About half a dozen specimens should be used, and the growth of each should be commenced about a week after the previous one. If a piece of charcoal be put in the water, it will act as an antiseptic, and do away with the necessity for changing the water. The first week's growth in each case had better be done in the dark, as the growth will be more rapid. The first specimen should be commenced at least six or seven weeks before the Lesson, so as to have the various stages well illustrated. The specimens should be kept in a fairly warm room, which should never be allowed to get too cold; about 60° F. will do. After the first week the specimens might be grown in the light and under the daily observation of the class.*)<br>Class to note :—<br>(*a*) The absence of rootlets and new leaves in the first case (fig. 15).<br>(*b*) Their presence in all other cases.<br>(*c*) The white, thread-like appearance of the rootlets.<br>(*d*) The greater length and number of the rootlets.<br>(*e*) The quicker growth of the rootlets than of the leaves.<br>(*f*) The increase in both roots and leaves in the older specimens.<br>(*g*) The shrinking of the bulb. | **The young plant wants food. Some of the food comes through the rootlets; hence their greater number and quicker growth. Each little rootlet is like a mouth sucking up food. The plants were grown in the dark for the first week in order to make the roots grow fast.**<br>(*g*) **The leaves and roots have grown at the expense of the bulb, *i.e.* they have fed on the food stored up in the bulb.** [Of course there is a limit to this growth.] |
| 4. A clay model might be made, to illustrate the growth at different stages.<br>Vary the instances. Some or all of the following might be used :—<br>(1) *Hyacinth Bulbs may be grown in the same way as the Onion.*<br>(2) *Some Mustard Seed could be grown on a damp pad or flannel, upon a sponge, or anything similar. The pad must be kept moist.*<br>(3) *Grains of Wheat might be grown in the same way.*<br>(4) *Some Broad Beans might be planted at different periods in a box of mould.*<br>(5) *Some Ears of Corn with very short stalks, placed in water a few days before the Lesson.*<br>(6) *An Acorn might be grown like the Onion.* | |

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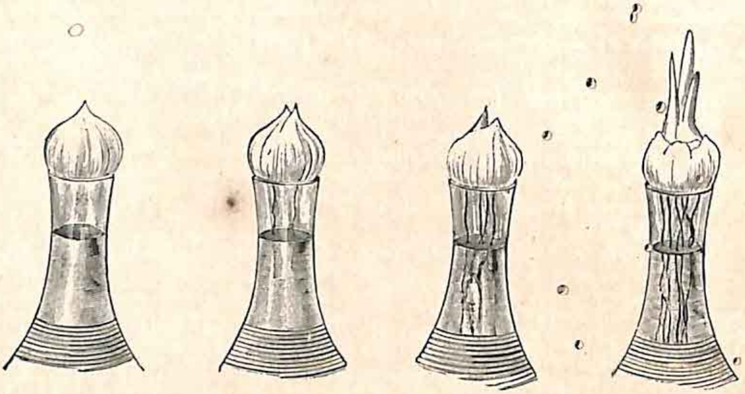


After 1 week. After another 5 days. After another 5 days' growth.

FIG. 15.

# HOW PLANTS GROW.

**Things required.**—*The teacher should first read through the Lesson, and see what apparatus is required and what preparation is necessary some days or weeks before the Lesson is given.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Take two German flasks (or two glass bottles), and fill one with water, leaving the other empty. Place a small onion on top of each, and see that in the one case it touches the water. Do this a week or two before the Lesson, and show the specimens to the class at the same time. | The one without water has not grown; the one with water has grown. | **Plants must have water.** |
| 2. Show two similar plants (a week or two before the Lesson) in flower-pots. Water one, and not the other. | The watered one lives, the unwatered one dies. | **Plants must have water.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. Take two other German flasks, fill them with water, and place a small onion bulb over each (*small, so that the food stored up in it may soon be consumed*). Do this some weeks before the Lesson. In one flask put a little saltpetre, gypsum, and calcium phosphate. Let the class see and know what has been done.<br>(*Teacher should not give these names to the children. It will be enough for them to know that some 'plant food' has been added.*) | Show the specimens to the class during the Lesson; the bulb over the water containing the saltpetre, &c., has grown most. If the experiment is started soon enough the water specimen will cease to grow as soon as the bulb is exhausted; the mineral specimen grows longer. | **Plants require proper food.**<br>[*A little 'fertiliser' will answer for this experiment.*] |
| 4. (*a*) Take three tumblers, and pour some warm water into each. In the first put a little *sugar*, in the second a little *salt*, in the third some *sand*; and let them stand for a time.<br>(*b*) Let one or two of the children *taste* the sugar and salt solutions respectively. Refer to sugar in tea, salt in soup, &c. | The sugar and salt have disappeared; the sand still lies at the bottom of the glass.<br>The sugar and salt are still in the water, but they have dissolved. | **Some substances are dissolved by water, and some are not** |
| 5. Refer to (2) again. The unwatered plant dies. *Why?* Both plants are in the same kind of soil, and the plant gets its food from the soil.<br>(*a*) Take a little soil; put it in a vessel containing some *distilled* water. (Ordinary water often contains mineral matter, and therefore will not do.) Shake up, and then let it settle. | There will be something at the bottom of the glass jar. | **This something is made up of things which will not dissolve in water.** |

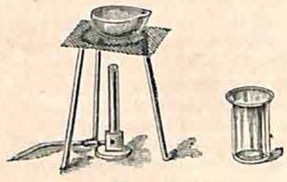


FIG. 16.

| | | |
|---|---|---|
| (*b*) Pour off the water into an evaporating dish (carefully), first asking the class to note that it looks fairly clear. Place the evaporating dish over a spirit-lamp, and keep it there until the water has boiled away. | There will be a something at the bottom of the dish. | **This something is made up of things which, like sugar and salt, will dissolve in water. Hence the need for watering the soil, so that the plant may have its food in a proper form.** |

An oral Composition Lesson should follow on the subject of the Lesson.

B.B. SUMMARY.

1. **Plants must have water.**
2. **Plants want proper food.**
3. **Plants want their food in a proper form.**

## HOW SEEDS GROW.

**Things required.**—*Specimens of broad beans or peas, acorns, beech seeds, cress, cabbage, castor-oil plant, pine, date, wheat or oat, boxes of mould or flower-pots, &c., to grow specimens.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Take some fresh seeds and some old seeds, and grow them in any of the ways shown in the Lesson on page 20. | The *old-seed specimen has either not grown at all*, or is backward compared with the fresh-seed specimen. | **Fresh seeds sprout more quickly and more easily than old ones (as a rule).** |
| 2. (*a*) Take some wheat or oat seeds which are several years old, but which have been kept dry, and grow them in the school (any seeds containing starch will do). | They sprout and grow. | **Seeds which have starch in them keep their power of sprouting for many years if kept dry.** |
| (*b*) Repeat Experiment with *old starch seeds* which have not been kept dry. | They may or may not sprout; probably not. | |
| 3. Grow *beans* or *peas* in the school. Plant at different times, so as to show different stages of growth. (*The teacher should experiment many weeks before the Lesson, so as to know when to plant the specimens required for the Lesson, and so as to have them in a suitable stage of growth. This will depend very largely upon the temperature at which the seeds can be kept, as well as upon the seeds themselves. Most seeds require from one to three weeks to sprout. Of course, some require months, and even years.*) | The young seed-leaves are thick and fleshy, and they remain within the seed during sprouting.<br>In older specimens the young seed-leaves have perished, and the young roots have forced their way into the ground.<br>Note the root is not branched. | **The young seed-leaves feed the young plant until the roots are grown enough to get their food from the soil.** |

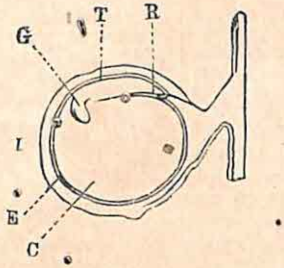


FIG. 17.—Pea with its coat cut through. C, seed-leaves; G, the young stem, enveloped in minute leaves; R, young root; T, axis of the young plant: I, outer, E inner skin (diagrammatic).

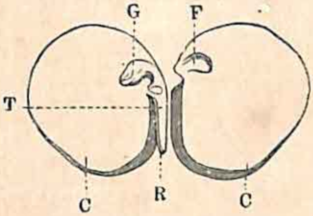


FIG. 18.—Pea split open and with the coat removed. F, small hollow in which the young stem lay; the other letters as in fig. 17. (Somewhat magnified.)

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 4. Grow *cress* and *cabbage* until the first leaves appear above the ground. (*Cress will frequently sprout in twenty-four hours.*) | The green leaves are the young *seed-leaves. They rise out of the soil, and carry the coats with them.* These leaves are thin. | **Same inference as in Experiment 3.** |

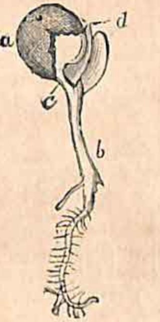


FIG. 19. — Sprouting seed of cabbage. *b*, axis; *c*, *d*, the two seed-leaves, which have risen above the soil, the coat, *a*, not being yet completely thrown off.

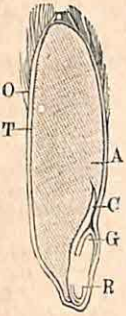


FIG. 20.—Longitudinal section of a seed of oat. C, the single seed-leaf; G, young stem; R, young root; T, coat; O, hairs.

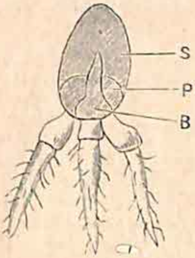


FIG. 21.—Grain of wheat sprouting. S, food matter; P, plate; B, first bud. Note the root is branched.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 5. Grow *wheat* or *oats* as in the previous Experiments. | The young seed-leaf grows into a plate, which remains in contact with the starchy food.<br>Note that there is only one seed-leaf. | **The plate-like seed-leaf takes the starchy food to feed the young plant.** |

### COMPARATIVE SUMMARY.

Inferences to Experiments 1 and 2.

| PLANTS WITH ONE SEED-LEAF | WITH TWO SEED-LEAVES |
|---|---|
| 1. Have a store of starchy food distinct from the seed-leaf. | No starchy food in addition to the seed-leaves. |
| 2. The seed-leaf remains wholly or partly inside the seed during sprouting. | (*a*) If the seed-leaves are fleshy they remain inside the seed until the food in them is used up (bean, pea).<br>(*b*) If the seed-leaves are thin they push their way out of the ground as green leaves. |

Oral composition to follow as usual.

## THE FORMS OF ROOTS.

**Things required.**—*A number of specimen roots ; e.g. the carrot or monks-hood, the turnip or turnip-radish, radish, sowbread, daisy or grass, orchid* (Orchis Morio), *dahlia, dropwort, Pelargonium triste, a cone, a spindle.*

OUTDOOR WORK.—The children should be taken to *gardens, fields*, &c., so far as possible, so as to see these plants growing in their natural surroundings. They should be *pointed out* to the children by the teacher, and *named* by him (or her), *so that the children may recognise them in their natural garb and position.* Probably all children know a turnip, a radish, or a carrot *out* of the ground, but experience has shown that many children do not know them *in* the ground ; to say nothing of the less common roots mentioned. Arrangements should be made (if necessary) to pluck one or more of the less common specimens for Classroom Work. The commoner roots can be easily obtained from their own gardens, from a friend's, or from a greengrocer's shop. So far as possible, for the Classroom Work the children should be invited to bring their own specimens.

CLASSROOM WORK.

1. The teacher must have a specimen of each root, either of those named in the Lesson, or other and similar roots of the same form. So far as possible the children also should be supplied with specimens. All these roots get their names from their form or shape.

2. Show a carrot or monks-hood root, and let the children note—
    (*a*) The root is broad at the base.
    (*b*) It is long.
    (*c*) It tapers towards the point.

Such roots are *cone-shaped*. Show a cone, and compare its shape. The children will then see the reason for the name.

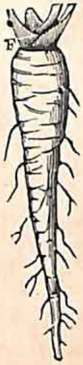


FIG. 22.—Conical root of the carrot.

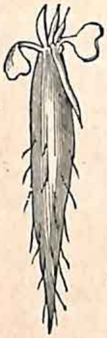


FIG. 23.—Spindle-shaped root of the radish.

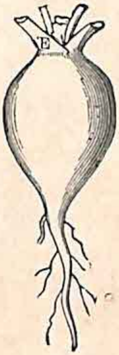


FIG. 24.—Turnip-shaped root of the radish.

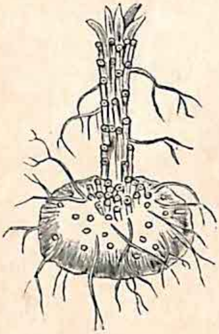


FIG. 25.—Root of sowbread.

3. Show the root of the radish, and note—
    (*a*) It is broadest in the centre.
    (*b*) It tapers towards both ends.

Such roots are called *spindle-shaped*. Show a spindle, and compare as before.

4. Show specimen of the turnip or turnip-radish.
    (*a*) It is somewhat like a globe or ball.
    (*b*) It tapers toward its end.

Such roots are called *turnip-shaped*.

5. Show specimen of the sowbread root. Note—
    (*a*) It has a stem-like portion.
    (*b*) The lower portion is like a flattened ball.
    (*c*) It is somewhat like the turnip, *but does not taper*.

6. Show the root of grass or of the daisy. Note—
    (*a*) There is not a single root, but a bunch of rootlets.
    (*b*) The thread-like appearance of these rootlets.

Such roots are called *fibrous* or *hairlike*.

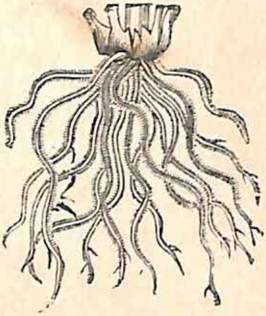


FIG. 26.—Hair-like root of a grass.

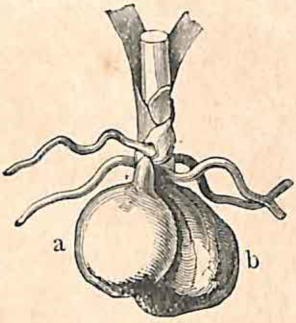


FIG. 27.—Potato-shaped root, *a*, *b*, of *Orchis Morio*.

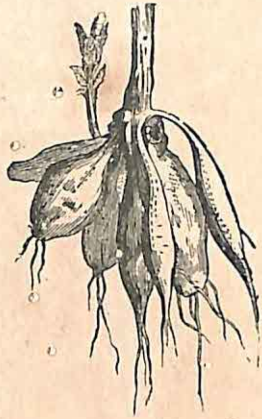


FIG. 28.—Tufted root of the dahlia.

7. Show specimen of the root of the *orchid* (*Orchis Morio*).
   (*a*) There are some fibres.
   (*b*) Some potato-shaped bodies, called tubers.
   (*c*) Some of the fibres have swollen into tubers.

   Such roots are called *tuber-shaped* or *potato-shaped*.

8. Show a dahlia root. Note—
   (*a*) The tuft of fleshy little tubers.
   (*b*) The rootlets at their ends.

   Such roots are called *tufted*.

9. Show the root of the dropwort.
   (*a*) There are a number of fibres like the daisy and grass.
   (*b*) These fibres are enlarged at their ends.
   (*c*) A number of tiny thread-like rootlets are given off on each fibre.

   Such roots have a knotted appearance, and are called *knotted*.

10. Show the root of the *Pelargonium triste*. It is like the last, excepting that there are several swellings, arranged like beads on a necklace, along each fibre. Such roots are called *necklace-shaped*.

## B.B. SUMMARY.

**Roots are :—**

**1. Cone-shaped.**
**2. Spindle-shaped.**
**3. Turnip-shaped.**
**4. Flattened ball.**
**5. Thread-like.**
**6. Potato-shaped**
**7. Tufted.**
**8. Knotted.**
**9. Necklace-shaped.**

Drawings and composition to follow as usual.

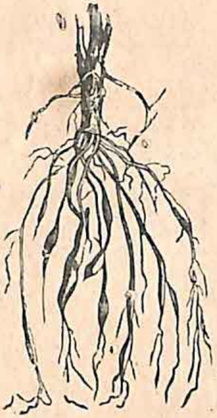


FIG. 29.—Knotted root of *Spiræa.*

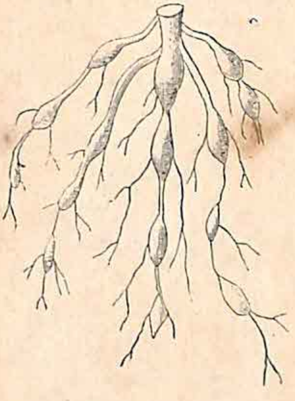


FIG. 30.—Necklace-shaped root of *Pelargonium triste.*

# A FEW CURIOUS ROOTS.

**Things required.**—*Specimens of carrots; the top of a carrot grown in water (several specimens illustrating the various stages of growth); daisy roots, strawberry roots, violet roots, Solomon's seal, iris.*

N.B.—*The Outdoor Work should be done during one of the school rambles.*

## CARROT. (*See Lesson on the Forms of Roots.*)

The top of a carrot should be cut off and grown in a saucer of water. Different specimens should be grown at intervals of about five days or a week, and all the specimens illustrating the different stages of growth should be ready for the Lesson. Call attention to the different specimens; *e.g.*—

A. Fresh specimen (fig. 31).

B. Same specimen after one week's growth in the dark (fig. 32).

Other specimens showing the growth for two, three, four weeks, &c., should be noticed in their turn. Observe—

1. The increasing growth of the leaves.
2. The putting out of little side rootlets.
3. The limited growth of the rootlets.
4. The carrot-top, growing less; **the leaves are feeding on it.**

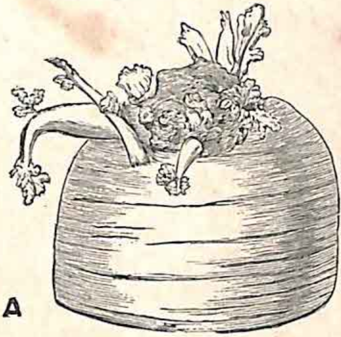


FIG. 31.

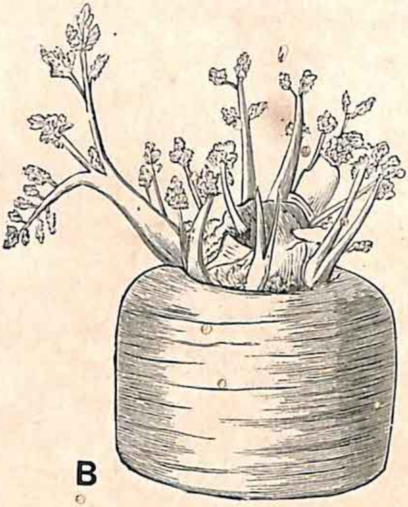


FIG. 32.

**DAISY.** (*See Lesson on the Forms of Roots.*)

Contrast the carrot with the root of the daisy.

## STRAWBERRY.

OUTDOOR WORK.—Take the class to a strawberry field, and let them see the specimens pulled up for the Lesson. Class to note its running stem.

CLASSROOM WORK.—Carefully clear the mould from the roots of the specimens, and with the aid of the Outdoor Work get class to note—

1. The long, slender, low-lying, running branch.
2. That this branch is given off from the base of the stem.
3. That it gives off leaves above and roots below, and thus grows a new plant.
4. That this new plant grows in a similar way.
5. The fitness of the name strawberry or strayberry.
6. That only in popular language are these roots. They are really stems, and are called runners.

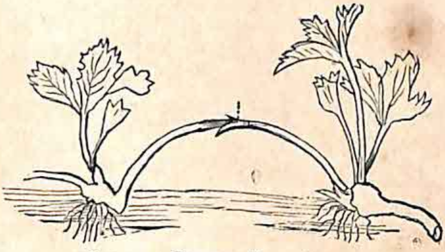


FIG. 33.—Runner of strawberry.

## VIOLET.

OUTDOOR WORK.—The children should be taken to fields or gardens to see the violets growing. Specimens might be dug up for Classroom Work.

CLASSROOM WORK.—Note—

1. The stem, which the class will remember is a runner.
2. It is long and thin.
3. The rootlets grow from the under side of the stem.
4. The leaves from the upper side.
5. Each node may or does bear a leaf-bud and roots.
6. Popularly it is called a creeping root.

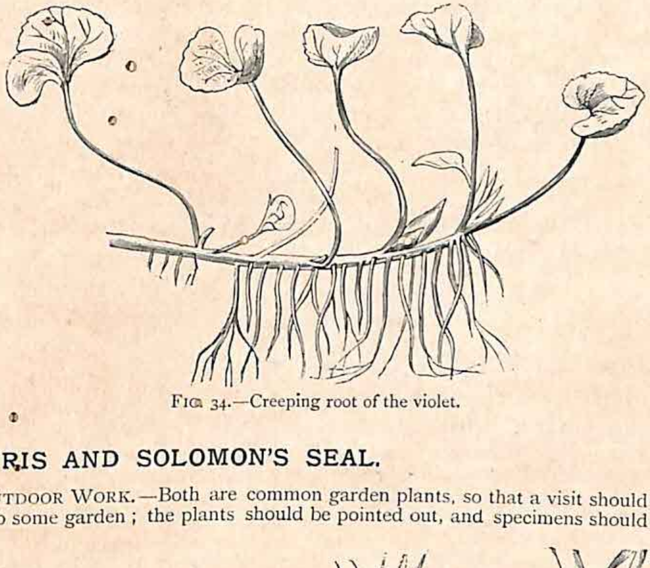


FIG. 34.—Creeping root of the violet.

## IRIS AND SOLOMON'S SEAL.

OUTDOOR WORK.—Both are common garden plants, so that a visit should be paid to some garden; the plants should be pointed out, and specimens should be

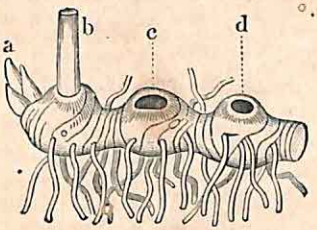


FIG. 35.—Root of Solomon's seal. *a*, end bud, from which is developed the next year's stem; *b*, this year's stem; *c*, *d*, scars of the stems of previous years.

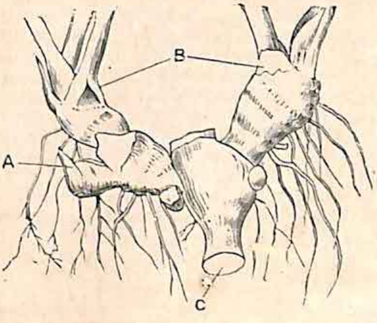


FIG. 36.—Root of the iris.

carefully dug up for Classroom Work. In addition, the children should bring specimens from their own gardens.

CLASSROOM WORK.—Note—

1. The creeping nature of the stem.
2. The position of the stem—generally partly beneath the ground.
3. The modes of extension or ways of growing :—

   Solomon's seal—by end buds. Point out the bud for next year's stem ; this year's stem ; the scars of the stems of previous years.

   Iris—by side buds. Point out the same features as in the Solomon's seal.

   Then, the Solomon's seal grows from its end, and the iris from its sides.

   These stems sometimes creep for long distances in this way.
4. The thick nature of each stem.
5. Popularly these are called roots, as the common name, rootstock, implies.

Nos. 1 and 2 will have been observed as the result of the Outdoor Work.

### B.B. SUMMARY.

**Some Curious Roots are :—1, Runners ; 2, Creepers.**

**Some Creepers grow :—1, by end buds ; 2, by side buds.**

Oral composition to follow as usual.

## THE SHAPE OF LEAVES.

**Things required.**—*Numerous specimens of each kind of leaf referred to in the Lesson, to distribute among the children ; leaf of a water-lily and the leaf of any plant grown in running water ; plant of the water crowfoot.*

OUTDOOR WORK.—In some of the *school rambles* the teacher should point out the plants the leaves of which he intends to use in this Lesson. Attention should be paid to the size and nature of the tree ; the arrangement of the leaves, their size, and whether fairly uniform or varying ; the thickness of the leaf-stalk, with special reference to the size of the leaf ; the generally narrower shape of leaves on shrubs than on trees ; the differently shaped leaves on different kinds of the same class of plants (*e.g.* the *Plantago media* and the *Plantago lanceolata*) ; the different shapes of the leaves under water, as compared with the leaves above water in water-plants (*e.g.* the *Ranunculus aquatilis*) ; the roundish shape of leaves which float on the surface of still water (*water-lilies*), as compared with the more or less lengthened leaves of plants which float on running water.

It is not suggested that the teacher should deal with every leaf in this Lesson. The length of the Lesson must determine the number dealt with, and the selection will mainly depend upon the leaves easily obtained in the district.

CLASSROOM WORK.

1. Distribute specimens of each kind of leaf to the children.
2. Sketch the object (sword, needle, &c.) on the B.B. which gives its name to the leaf. Where possible show the object itself (*e.g.* needle, egg, hand, feather, &c.).

3. Then ask each child to pick out the leaf which most nearly corresponds to the object in shape.

    (Probably some mistakes will be made by the children at this stage; these mistakes will be the teacher's opportunity. He will be able to compare the mistaken leaf with the right one, and so draw attention to little points of difference or likeness which have escaped the notice of the child. This will make the lesson a very valuable one for training in habits of careful observation.)

4. The name should then be given (*not* the technical one), and the reason for the name will be obvious to the children.
5. The leaf should then be rapidly sketched on the B.B. by the teacher, but no name should be written on it or under it. The children must learn to recognise the *form* of the leaf from the similarity of its shape to the object concerned.
6. The name of the plant from which the leaf comes *may be given*. At the end of the lesson the children should then be exercised in giving the plant-name from the recognition of the leaf itself.
7. The parts of the leaf in each case should be pointed, and named—*blade, stalk, stipules*—so that the children may learn to distinguish a perfect leaf from an imperfect one. Where any one part is wanting the leaf is imperfect.

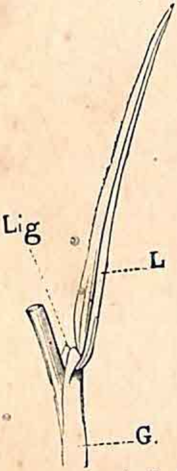


FIG. 37.—Leaf of grass. L blade; G leaf-sheath.

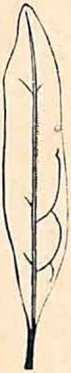


FIG. 38. — Lance-shaped leaf of the privet.

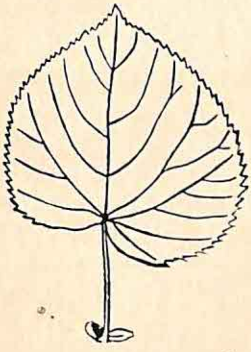


FIG. 39. — Heart shaped leaf of the lime.

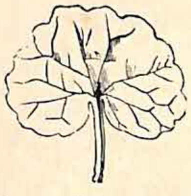


FIG. 40.—Kidney-shaped leaf of the ground-ivy.

AFTER LESSONS:—

1. The teacher may follow with a *Kindergarten* lesson. The children may prick the leaves off on paper and cut them out, giving the form-name, and the plant-name in each case.
2. Or they may *draw* round them and cut them out, and then proceed as in 1.
3. Or they may simply *draw* round them, but always naming each completed specimen.
4. Or they may *sketch* them from the B.B.

Oral composition should follow.

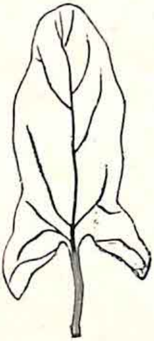


FIG. 41.—Arrow-shaped leaf of convolvulus.

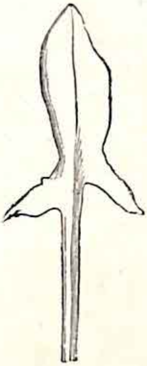


FIG. 42. — Spear-shaped leaf of the dock.

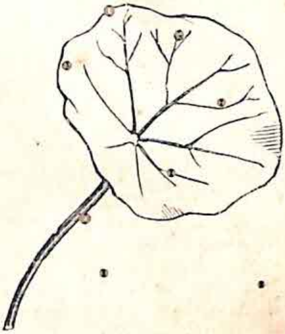


FIG. 43.—Shield-shaped leaf of nasturtium.

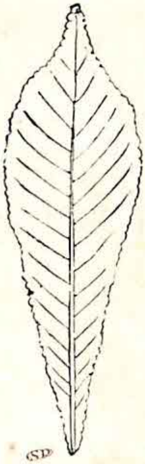


FIG. 44.—Wedge-shaped leaflet from the leaf of the horse-chestnut.

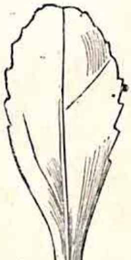


FIG. 45.—Spoon-shaped leaf of the ox-eye daisy

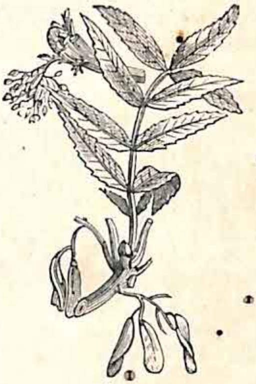


FIG. 46.—The ash.

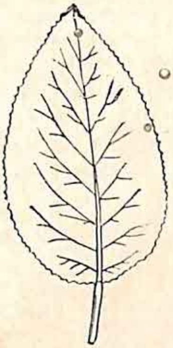


FIG. 47. – Tooth-edged, egg-shaped leaf of the guelder rose.

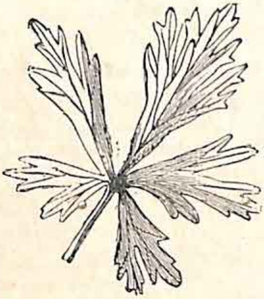


FIG. 48.—Hand-shaped leaf of the monks-hood.

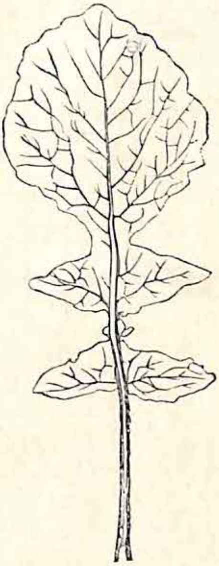


FIG. 49. – Lyrate leaf of the white mustard.

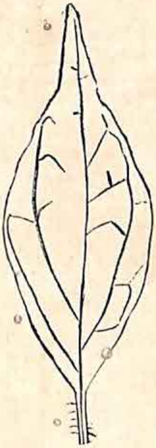


FIG. 50.—Sharp-pointed leaf of the pellitory.

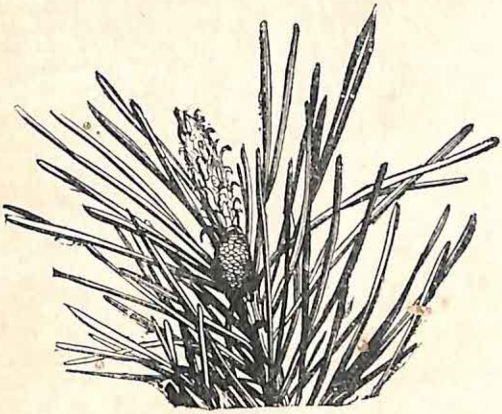


FIG. 51.—Needle-shaped leaves of the Scotch fir.

## VEINS OF LEAVES.

**Things required.**—*Prepared skeleton specimens of all the leaves named in the lesson; fresh or dried specimens of the same leaves for distribution among the children; a feather.*

OUTDOOR WORK.—In some of the school rambles the teacher should point out the trees and plants, the leaves of which it is intended to use in this lesson. The children might be invited to notice the size, position, and leaf arrangement of the plant; whether the plant is in a lofty or a lowly position; whether exposed or sheltered; whether a land plant or a water plant; and whether on a dry soil or a damp one. *The object is to associate each leaf with the plant from which it is plucked, and so to call up a mental picture of the plant in its natural surroundings when the leaf is presented to the class.* Plenty of dried skeleton leaves can be found in the late autumn.

CLASSROOM WORK.—Other leaves than those here chosen will do, provided they illustrate the same vein structure.

1. Show the skeleton leaf of the *guelder rose*, and note the one single principal vein (mid-rib). Then ask the children to pick out the leaf of the guelder rose (fig. 47) from their specimens. The teacher will hold up a specimen leaf in front of the class for their guidance. **Then some leaves have one principal vein.**

2. Hold up the skeleton specimen again and let class note that the smaller veins curve towards the top point (apex). As before, then let them recognise this arrangement in the fresh specimens—**curve-veined.**

3. Proceed in the same way with the leaf of the *dandelion*; first the skeleton specimen, then the fresh one. There is one principal vein, but the smaller veins stand out straight to the edge of the leaf. Compare this leaf with a feather. The leaf is called **feather-veined.**

4. Proceed in a similar way with all the other leaves, and note the differences in the vein arrangement.

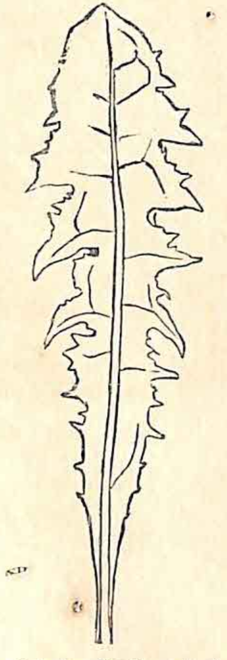


FIG. 52.—Feather veined leaf of the dandelion.

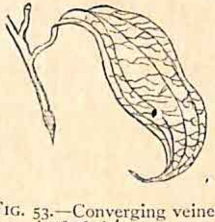


FIG. 53.—Converging veined leaf of cinnamon.

5. Examine *maple* or *castor-oil plant* leaf. There are several principal veins, and they never meet again. Compare with the palm of the hand. Such a leaf is called **palm-veined.**

6. Sketch a *cinnamon leaf* on the B.B. There are several principal veins, and they do meet again (*converging*). **The veins meet.**

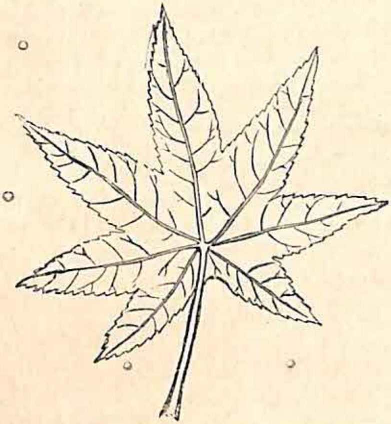


FIG. 54.—Palm-veined leaf of the castor-oil plant.

7. Examine a *blade of grass* (fig. 37). The veins all run straight to the point of the leaf. Such a leaf is called **straight-veined.**

8. Show the skeleton specimens of the first five leaves, and ask class to note that the veins look more or less like a net. All such leaves are called **net-veined.**

### B.B. SUMMARY.

Veins form the framework of the leaf.

1. Net-veined
   - One principal vein
     - Curve-veined.
     - Feather-veined.
   - Several principal veins
     - Palm-veined.
     - Net veins meet.
2. Straight-veined.

## THE ARRANGEMENT OF LEAVES.

**Things required.**—*Specimen twigs or small branches, so as to show the arrangement of the leaves.*

OUTDOOR WORK.—One school ramble could be made sufficient for the outdoor work for this and the two preceding Lessons. For the purpose of this Lesson the teacher should seize each opportunity to point out the different arrangements as they present themselves. As the same arrangements present themselves again the children should be invited to name the arrangement, and this will afford plenty of opportunity for those corrections and explanations which are almost inevitable and which are so valuable for training in habits of careful observation.

Classroom Work.—Any other leaves showing the same arrangements will do.

1. Hold up a twig or small branch of the *oak* and note the arrangement of the leaves round the stem. They come one above the other on opposite sides of the stem.
2. Hold up a stalk with leaves of the *dead nettle*. The leaves still come one above the other, but they are in pairs, and opposite to each other.
3. Show a plant of the *scarlet pimpernel*. The leaves are opposite in pairs, as in the last case, but they are at right angles to each other. (Explain *right angle* if necessary.)

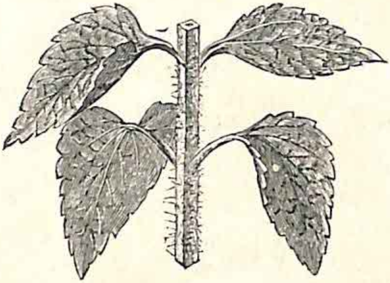


Fig. 55—Dead nettle.

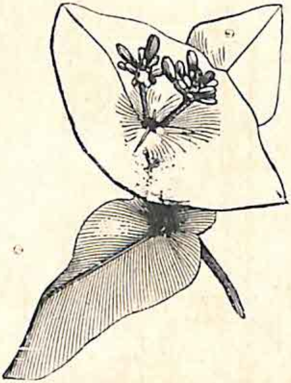


Fig. 56.—Leaves of the honeysuckle.

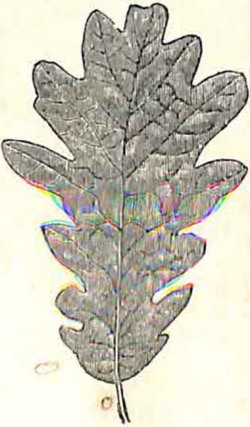


Fig. 57.—Leaf of the oak.

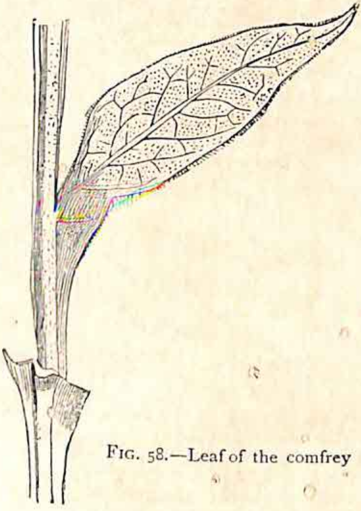


Fig. 58.—Leaf of the comfrey

4. Show the stem and leaves of the *goose grass* or *madder*. There are more than two leaves, and they are in a ring round the stalk.
5. Show leaves and stalk of the *honeysuckle*. Note that the two opposite leaves have their ends so joined together as to seem to form but one leaf, sometimes thus making a cup, as in the *common teasle*.
6. Show the *hare's ear*. The stem grows through the leaf.
7. Show the leaves and stalk of the *comfrey*. One part of the leaf is fixed to the stem, causing it to look like a wing.
8. Show a *primrose plant*, and note that the leaves grow from the top of the root.
9. From any suitable specimens show that—
   (*a*) **Some leaves are stem leaves ; *i.e.* they grow from the stem.**
   (*b*) **Some are branch leaves ; *i.e.* they grow from a branch.**
   (*c*) **Some leaves are flower leaves ; *i.e.* they grow from flower stalks.**

RECAPITULATORY EXERCISES.—A number of other specimens illustrating the various kinds of arrangement should be provided for the lesson. Each specimen should be held up to the class for examination and then placed, under the direction of the children, in its proper class.

Oral composition to follow.

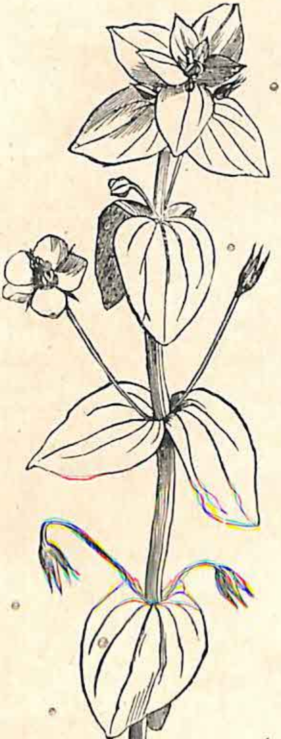


FIG. 59.—Leaves of the scarlet pimpernel.

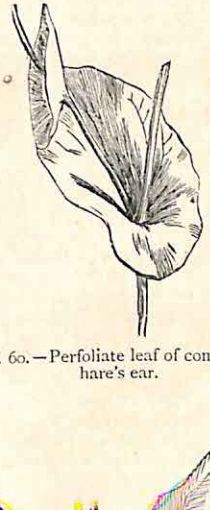


FIG. 60.—Perfoliate leaf of common hare's ear.

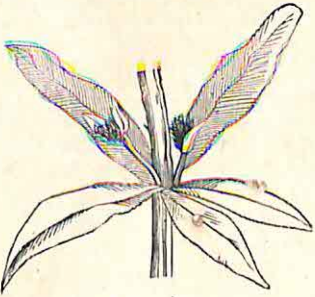


FIG. 61.—Leaves of the madder.

## THE CAT (FIRST LESSON).

**Things required.** – *A cat or kitten, good pictures of the cat, a saucer of milk, a bit of meat, a biscuit or piece of bread, a cat's skull with teeth, a dog.*

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **BODY.** | | |
| 1. Let the cat stand up on its legs. Call attention to the body; it is long and strong looking. | | |
| 2. Stroke the fur the right way and ask class to listen; there is no sound. | These qualities of the body enable the cat to move about without making a noise. | **Its body is so formed and covered as to fit it to hunt its prey.** |
| 3. Call attention to the size and shape of the head; it is small and round, and small in proportion to the bulk of the body. | | |
| **MOUTH.** | | |
| 1. (*a*) Give the cat a piece of meat and let it eat it on a table before the class. | | |
| (*b*) Note that the jaws move up and down only. Now bring a boy out in front of the class and ask him to eat a piece of biscuit. Note that his jaws move up and down and from side to side. | The cat neither *cuts* nor *chews* its food, but *tears it* and *swallows the torn piece whole.* | **There is no chewing; hence no need for the side movements.** |
| 2. (*a*) Show a bone that has been cleared of its meat by a cat. (The experiment may be done in front of the class if the cat has been kept somewhat hungry, and there is not too much meat on the bone.) | The meat is torn from the bone by means of the teeth. The bone is then licked or scraped clean by the rough tongue. | **The tongue is a scraping organ.** |
| (*b*) Call out a child in front of the class. Pour a little milk into its hand. Let the cat lick it up. Its tongue is rough. | The roughness is caused by little hooks all over the tongue, which point backwards. This action is called lapping. | |
| 3. Then place a little milk in a saucer on the table and let the cat have it. Note the action of the tongue. Contrast it with our method of drinking. | | **The tongue is a lapping organ.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 4. Show a cat's skull with the teeth. Note that the cutting teeth are small; the tearing teeth very long. There are no grinding teeth. | The edges of what are usually grinding teeth are pressed together so that they may be used for cutting. | **The teeth are suited for eating flesh** |
| **EYES.** | | |
| In sunshiny weather we let down the blinds, or if we have to look sunwards place our hands above our eyes, the object being to regulate the amount of light. When does a cat chiefly hunt its prey? At night. | The cat's eyes are made in a special way. The pupil gets smaller and this fixes the quantity of light. The pupil gets smaller by day and larger by night. The eyes are shielded by curtains. | **The cat hunts mice in the dark, and so must be able to see in the dark.** |

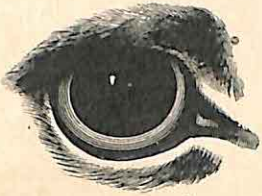


FIG. 62.—Cat's eye by night.

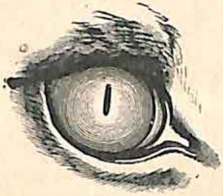
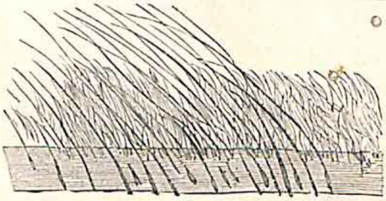
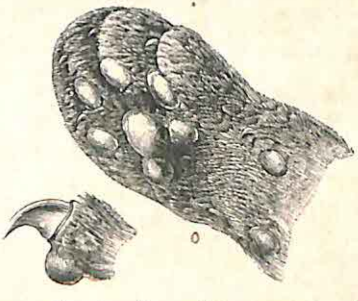


FIG. 63.—Cat's eye by day

## THE CAT (SECOND LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **WHISKERS.** | | |
| 1. Note the cat's whiskers. They stand out straight from each side of the face. Touch them and the cat *turns its head*. (An over fondled cat sometimes takes no notice. In such a case try again, only 'a little more so.') | Children sometimes, in error, call them 'smellers.' They give notice of anything in the cat's path at night, or tell the size of a hole through which it wants to creep. | **They are for feeling and measuring. By means of them the cat feels things in the way and measures spaces.** |
| 2. Note the size of the head again; it is smaller than the body. Note the extent of the whiskers from root to tip; they extend the width of the body. Hence, where the whiskers can go untouched the body can go. | | |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **FUR.** | | |
| 1. Let some of the children feel the cat's fur; it is thick and warm. |  FIG. 64.—Overhair and fur of cat. | **The cat is a night animal, and therefore needs warm fur.** |
| 2. Elicit that a well-fed cat has a 'nice' coat; a stray or neglected cat has not. | There is overhair growing through the fur. [Sketch on B.B.] Sooner or later a cat licks itself after every meal. The cat is fond of warmth:<br>(*a*) It sits in the sun.<br>(*b*) Or before the fire.<br>(*c*) It seeks something warm to sleep on. | **Good food improves the look of the coat.** |
| 3. Refer to the cat's habit of licking its fur—of washing itself. It does this very often. | | **The cat is a clean animal.** |
| 4. Introduce a dog into the room. Ask the children to note the condition of the cat's fur and back. The back is arched and the fur stands on end. Compare with our 'creeping' of the skin. | | **Anger or terror may be shown by the fur.** |
| 5. Ask children if they have ever seen a cat wash itself with water or go for a swim. | The cat does not like water. Contrast with the dog. | **The fur is not oily, hence the water clings to it. Contrast with the duck.** |
| **FEET.** | | |
| 1. Let some of the children examine the cat's *feet*. There are four pads. Let them feel them; they are soft. |  FIG. 65.—Paw and claw of cat. | **The soft pads enable it to move without making a noise, so that it can approach its prey ready for its spring.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. Examine the front and hind feet for claws. There are five on the fore-foot and four on the hind-foot. | | **There are more claws on the front feet, because:—**<br>**(*a*) The cat seizes its prey with its front claws.**<br>**(*b*) The chief strain is on the front claws when climbing.** |
| 3. Get the cat to put out its *claws*. When not put out each claw is resting in its sheath. | The sheaths are to protect the claws. | **If the claws were always put out the cat would find it very difficult to walk.** |
| 4. Ask class if they have ever seen the cat scratching the leg of a chair or a table, or the floor, &c. | The cat climbs trees, walls, &c., easily. | **This is done to keep the claws sharp.** |
| **TAIL.** | | |
| 1. Note the cat's *tail*. It is large. | | |
| 2. Elicit by questioning :—<br>(*a*) Sometimes it droops. | This is its ordinary position. | **The cat shows its feelings by means of its tail.** |
| (*b*) At other times, when crouching, the end waves to and fro.<br>(*c*) Sometimes it is stiff and upright. | Both of these denote pleasure. | |
| (*d*) Sometimes the cat lashes with it. | This denotes anger. | |

Oral composition should follow.

## THE DOG (FIRST LESSON).

**Things required.**—*A dog, not too small a specimen ; picture of a greyhound ; a dog's skull, with teeth ; a biscuit.*

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **BODY.** | | |
| 1. (*a*) Note that *body* is larger (generally), longer and stronger looking than that of the cat. The chest is deeper than the cat's. Note the thin loins. | The deep chest and slender loins fit it to run fast and a long way before getting tired. In a wild state the dog had to run down its prey. | **The body is formed to fit it for the chase. The deep chest gives it great lung power, *i.e.* prevents it getting out of breath too soon.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| (*b*) When we run we 'get out of breath'; hence, to run well we want among other things to have big lungs to hold plenty of air (breath), and big lungs want big chests to hold them. | | |

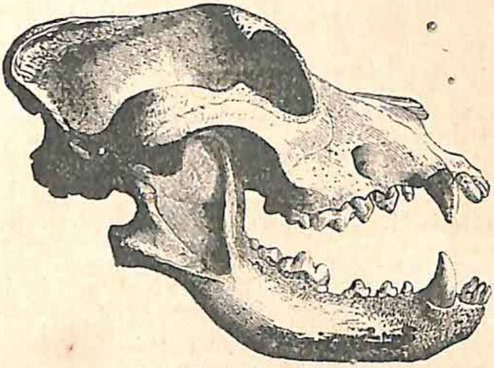


FIG. 66.—Skull of the dog.

## HEAD.

| | | |
|---|---|---|
| 1. Note the *head*. It is small, *but longer than the cat's*. Note the pointed nose. | The dog has a keen sense of smell. In the streets we observe that it smells everything. | **The longer head is wanted so as to bring the nose nearer the ground. The pointed nose and keen sense of smell are wanted, because the dog hunts by scent.** |
| 2. Observe the ears. In some dogs they droop; in some they are erect (this will depend upon the type of dog shown). Speak to the dog, or make any sudden noise, *and watch the dog's ears*, they are raised erect at once. | The ears are *erect* in wild dogs. | **The tame dog has lost the need for always being on the look out against foes; hence its drooping ears.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. Tame dogs bark; wild dogs never bark. | Tame dogs also utter other sounds to express different feelings. | **Barking would tell the wild dog's enemies where it was.** |

## EYES.

| | | |
|---|---|---|
| Note that these are large, but that they are not 'curtained' like the cat's. | They do not get smaller and larger like the cat's. | **The dog hunts by day and by scent; hence eyes like the cat's are not wanted.** |

## WHISKERS.

| | | |
|---|---|---|
| 1. Note that these are short and weak. | Very little use for the whiskers, because the dog *is not a night animal*. | **As in the cat, the whiskers will be used for feeling in the dark.** |
| 2. There are no feelers. | There is no need for them. | **Because the dog is not a night animal and it has not to pass through holes, like the cat.** |

## TEETH.

| | | |
|---|---|---|
| 1. Show the dog's skull with *teeth*, and note that there are teeth for cutting, tearing, and grinding. | If the teacher does not possess a dog's skull, a docile dog should be obtained, and its mouth held open by its owner or a person who is known by it. Then sketch the mouth. The dog's teeth are not so strong as the cat's. | **The front teeth are for biting or cutting; the long teeth for tearing; the back ones for grinding.**<br>**In our case the double action of the jaw is wanted to chew our food; but not in the dog, which, like the cat, bolts its food whole.** |
| 2. The last of the front grinding teeth in the upper jaw, and the first grinding tooth in the lower jaw, are larger than any others, and bite against each other. | | |
| 3. The teeth are *strong*, *sharp*, and *pointed*. | | |
| 4. Give the dog a biscuit, and ask the class to note the action of the *jaws*. Then bring a boy out in front of the class. and let him eat a piece of biscuit. Class to note the different action of the jaws, from side to side as well as up and down. | | |

## THE DOG (SECOND LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **LEGS, PAWS, AND CLAWS.** | | |
| 1. (*a*) Show the dog's legs and note they are thin, but strong. | The dog is a swift runner, a good swimmer, and climbs and leaps well. | **The legs are formed for running. Good running powers are wanted by an animal which hunts its prey.** |
| (*b*) Show the picture of the greyhound, and call attention to the very thin legs. | | |
| 2. (*a*) Show the dog's foot, and let the class examine it. The paws have pads and claws. Note that the claws are strong, but shorter and blunter than the cat's. They are either curved or nearly straight. *Count them.* There are five on the fore foot and four on the hind foot. | The claws cannot be drawn in and out like the cat's. They wear out quickly from constant use, but grow again quickly. | **The dog's step is not so quiet as the cat's, because its pads are harder and the claws cannot be drawn in. There is not the same need. The cat comes near its prey quietly, ready to spring; the dog hunts its prey as soon as it is seen.** |
| (*b*) Let the dog walk along the table, and note the action of the toes. It walks on its toes like a cat, but has not its quiet step; it rests on the last joint of its toes in walking. | | **The claws are formed for scraping (a dog can scrape a hole in the ground large enough to put its body in).** |
| **COVERING.** | | |
| Point to the dog's coat. It is hair, and not fur. The hair is thick, smooth, shaggy, long, short, &c., according to the specimen dog shown. | Hair is not so warm as fur. The hair, as in the cat, gets thick in winter and light in summer. | **The dog is not a night animal, and therefore does not want a fur coat.**<br>**The coat grows to suit the weather.** |
| **TAIL.** | | |
| 1. Note its usual position and appearance: generally long and curled upwards. | In bull dogs and terriers the tail is short. | |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. Note its movements. Speak to the dog kindly, the tail is lowered and wagged. | | |
| 3. Frighten the dog, the tail is put between the legs. | | **The tail is used to show its feelings.** |
| 4. Sometimes the tail is *stiff*. | The stiff tail may often be seen in dogs when hunting or fighting. | |

USES.—As a *guide* and *guardian* (sheep and houses); for *draught* (in foreign countries); for *sport* (hunting, coursing, &c.); for *saving life* (drowning, snow, fire); for *food*; for *skins* in manufactures; for domestic *pets*.

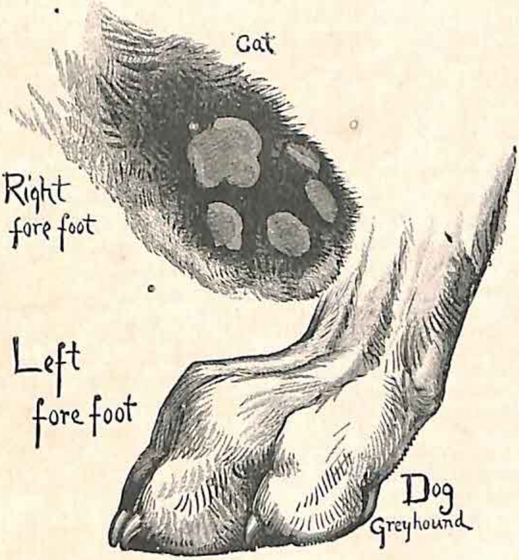


FIG. 67.

## THE CAT (Compared with the Dog).

| | CAT | DOG |
|---|---|---|
| 1. **Habits.** | A *night* animal. Hunts by *sight*. Attached to *places* rather than persons. Cunning, patient, cruel to prey, intelligent. | A *day* animal. Hunts by *scent* principally. Attached to *persons* rather than places. Faithful, affectionate, and very intelligent. |

| | Cat | Dog |
|---|---|---|
| 2. **Body.** | Long and powerful. Less variation in size than in the dog. | Heavier, and deeper chested. Varies much in size. |
| 3. **Head.** | Roundish and small. | Longer and larger. |
| 4. **Eyes.** | Change shape. The size of the pupil varies according to the amount of light. | No change like the cat's. |
| 5. **Whiskers.** | Long and sensitive. Has feelers. | Short and weak. No feelers. |
| 6. **Teeth.** | For *cutting* and *tearing*. | For *biting*, *tearing*, and *grinding*. |
| 7. **Tongue.** | Rough and dry; covered with little hooks which point backwards. Formed for *scraping*. | Wet and smooth. |
| 8. **Covering.** | Fur. | Hair. |
| 9. **Feet.** | *Claws* sharp, curved, can be drawn in and out; *sheathed*; feet have *soft pads*. | Claws strong, but blunter, shorter, and straighter. *No sheath* and *harder pads*. |

Oral composition to follow.

## THE COW (Compared with the Sheep and Goat).

(FIRST LESSON.)

**Things required.**—*Pictures of the cow, sheep, goat; a small piece of cow's skin with hair attached; ditto goat's skin; cow's skull and sheep's skull; a piece of cow's horn; specimens of feet, if possible; drawings of cow's and sheep's stomach; a piece of goat's horn, if possible.*

OUTDOOR WORK.—During many of the school rambles the children will have often seen cows grazing in the fields. Sometimes they will have been seen lying down chewing the cud. The same will be true of sheep, but goats are more rare in this country.

CLASSROOM WORK.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **BODY.** | | |
| From the picture and from their knowledge of the cow, the class to note that the *body* is thick, and heavy, and of different colours. It is bigger than that of the sheep or goat and nearly as large as that of the horse. The *neck* is rather short and thick. The body of the goat is somewhat different in shape to that of the sheep. | The pictures used should show relative sizes.<br>The mountain habits of the goat will account for its different shape. | **A short neck in a large animal is bad for grazing. The sheep and goat are not so badly suited as the cow seems to be, because, being smaller, they are nearer to the grass.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **COVERING.** | | |
| 1. Show the piece of *cow's* skin. Let class feel it; it is stout and strong and covered with a rather short hair. | Some cows have shaggy coats. The cow is very hardy and easily suits itself to changes of soil, climate, and treatment. | **The skin is useful for making leather.**<br>**The short hair causes it to be troubled with insects in hot weather.** |
| 2. The *sheep* is covered with wool. Hand round a piece of wool to class and let them notice its soft, oily touch. | The sheep are *sheared* of this wool each spring. Briefly describe the process. | **The sheep needs warm clothing because it lives night and day in the open air.**<br>**Nature suits the covering to the season.** |
| 3. Show the piece of *goat's* skin with hair. The hair is longer than the cow's. | Wild sheep 'shed' their wool, and tame ones would do the same if they were not sheared.<br>Question as to the warmth of woollen clothing. | **The long hair is for warmth. The goat is a mountainous animal, and is found at great heights, where the air is very cold.** |
| **HEAD.** | | |
| 1. Show the cow's skull and note that the head is large and long with a broad, flat forehead. | In the wild state such animals as the cow dwelt on large grassy plains and were the special prey of such wild animals as the lion, tiger, &c.; hence the need both for good eyesight and good hearing. Such animals would in some measure trust to flight for safety. When we run we breathe very hard and quickly; hence the value of the wide nostrils. | **The long head in each case helps out the short neck in grazing.**<br>[Compare with the horse.] |
| 2. Point to the picture and ask class to note that the nose is broad and square, and the nostrils are not covered. Note also that the eyes are large and gentle-looking. | | **The large open nostrils are wanted, as all breathing is done through them.**<br>**The large eyes would help the cow to see its enemies readily.** |
| 3. Point to the *ears*. They can be raised erect in an instant. | | **When the ears are raised the cow can hear better and is thus sooner warned of danger.** |
| 4. Show the *sheep's* skull. It is smaller than the cow's, but the forehead is much the same shape. | | |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 5. The *goat's* head must be studied from the picture. Both sight and smell are strongly developed. | The goat is a mountain animal, and the sheep is found both on hills and plains. | **Both specially fit it for its mountain life.** |

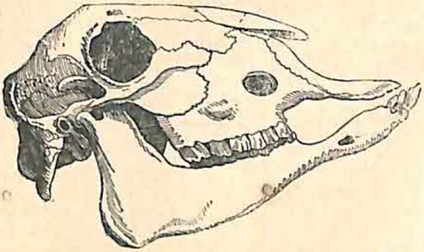
## HORNS.

| | | |
|---|---|---|
| 1. From a study of the pictures it will be noticed that all three of these animals, in some cases at least, have horns. In the *cow* they are long and generally curved upwards and outwards. | The cow's horns are hollow, smooth, hard, and strong, and they are formed from the skin, like our nails.<br>Refer to the acts of tossing and goring. Ask when and why the ox does these things.<br>(If the teacher is fortunate enough to get possession of a complete horn, so much the better for this part of the lesson.) | **The horns in all three cases are for defence. Their hard, strong nature, their shape, and their position, all make them suitable for this purpose.** |
| 2. Show a piece of cow's horn and elicit the facts given opposite. | | |
| 3. In the *sheep* (from the pictures and from Outdoor Work) note that the horns of the ram are larger than those of the ewe. | Attention ought to have been called to this difference during the outdoor rambles. | **The male wants bigger horns, because the chief work of defence falls upon the males. The same is true of the goats.** |
| 4. From the picture and from Outdoor Work note that the horns of the *goat* are long, sharp, and wrinkled. Examine a piece of goat's horn. Both males and females have horns, but they are much longer in the males, reaching three feet in some cases. | An examination of a horn would show it to consist of a solid core of bone, surrounded by a horny sheath. The outside is roughened by some ridges, which are placed crosswise, and there is a long ridge in front which runs lengthwise like a keel.<br>The goat is a bold animal in attack, and the old males | **The horns of the goat are used to fight rivals or foes, and for defence generally.** |
| are cross and too ready to fight. the goat's temper is uncertain. | Speaking generally, | **Children should take care not to tease goats.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 5. From a *comparison* of the goat's and sheep's horns, note that the goat's differ from the sheep's :<br>(*a*) *In their position at the top of the head.*<br>(*b*) *In being curved backwards.*<br>(*c*) *In being pressed together at the sides.* | | |

## THE COW (Compared with the Sheep and Goat).

(SECOND LESSON.)

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **TEETH.** | | |
| 1. Show the cow's skull and note that the front lower jaw has broad cutting teeth, and that there are grinders in each jaw. Note that there are no biting or tearing teeth opposite to each other. | | **The cow could not eat flesh, because there are no biting or tearing teeth.** |
| 2. An examination of the cow's mouth would show that the gums in front of the upper jaw form an indiarubber-like pad. | In grazing, the cow twists its long tongue round a tuft of grass, which is then pressed with the teeth of the lower jaw against the pad and jerked off. | **When eating, the hay or cut grass must be conveyed into the mouth by the tongue alone.** |
| 3. The sheep's teeth and mouth are like the cow's. This can be learned largely from a comparison of the two skulls. The goat's are also similar. | <br>FIG. 68.—Skull of the sheep. | |

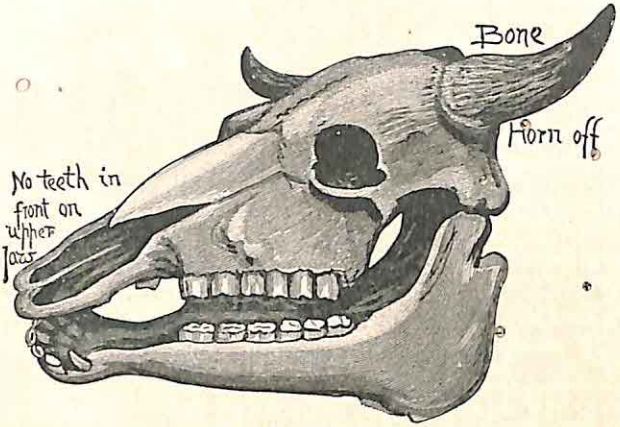


FIG. 69.—Cow's skull.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **LEGS.** | | |
| 1. From the pictures note that the legs of the *cow* are short and thick in the top part, but smaller below, and strong. | Wild cows are very swift. | **They are suitable to support the weight of such a big body.** |
| 2. In the *sheep* they are thin but strong. | A mountain sheep is swifter than a meadow sheep. | **The mountain sheep is hardier and "fitter" because of its mountain life.** |
| 3. The legs of the *goat* are long and slender, but *very strong*. | The goat is a better climber, swifter, and more active than either the sheep or the cow. | **The goat is better built for these purposes, especially in the legs.** |
| **FEET.** | | |
| 1. Note that they are *all shaped alike*. They are even-toed and cloven hoofed. The two middle toes reach full length, the other two being at the back of the foot and very small. The feet are broad and have a hard, horny covering. | | **The cow's feet are formed to suit the damp fields, where it is found. With the great weight of the cow's body above a sharp or pointed hoof, the feet would sink into the ground.**<br>**The cow grazes damp fields because grass grows best there.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. In the *sheep* the feet are also cloven. Only the third and fourth toes are present, the others being missing. | Large numbers of sheep, especially in foreign countries, feed on the sides of mountains. | **The sheep's feet are better suited to hill work than the cow's.** |
| 3. The feet of the *goat* are small, with sharp hoofs. | Both sheep and goats are remarkably *sure-footed*, and goats especially so. | **The goat's feet are specially formed to suit its mountain climbing.** |

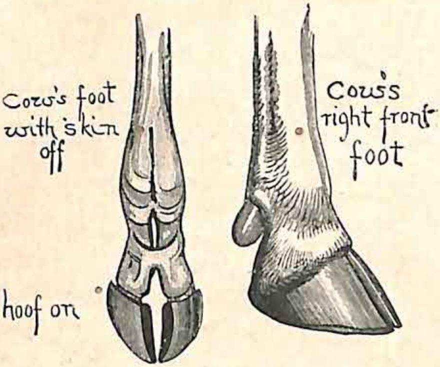


FIG. 70.

## TAIL.

| | | |
|---|---|---|
| 1. From outdoor observation it should have been noticed that the *cow's* tail is long and tufted, that it has free movement, and can be twisted to almost any part of the body. | | **The cow's tail is long and tufted, and has free motion so as to enable it to drive away the flies in hot weather.** |
| 2. The *sheep's* tail is generally short; so is the goat's. | A lamb's tail is generally cropped, but the tail is long, if allowed to grow. Some sheep have enormously big and fat tails. | **The sheep's body is covered with wool, which protects it from insects; hence its tail is not wanted for the same purpose as the cow's.** |

## THE COW (Compared with the Sheep and Goat).

(THIRD LESSON.)

### CHEWING THE CUD.

1 Sketch the cow's stomach. Point out that there are really four stomachs.

A. Third Stomach.
B. Second Stomach.
C. Fourth stomach.
D. Paunch.

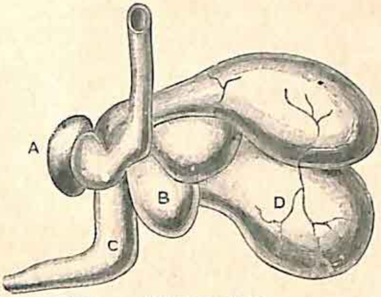


FIG. 71.—Stomach of ox.

2. Sketch the sheep's stomach and compare the two, paying special attention to the points of similarity.

3. Describe the process of 'chewing the cud.' When lying down the cow brings back the bunches of grass into her mouth and chews them thoroughly. Remember the grass has been in the paunch for some time soaking. It then passes into the second stomach, stays there a short time, and is then brought back into the mouth to be *chewed*. After chewing it passes into the third stomach, and thence into the fourth, or true stomach, where real digestion begins. The sheep and the goat also chew the cud.

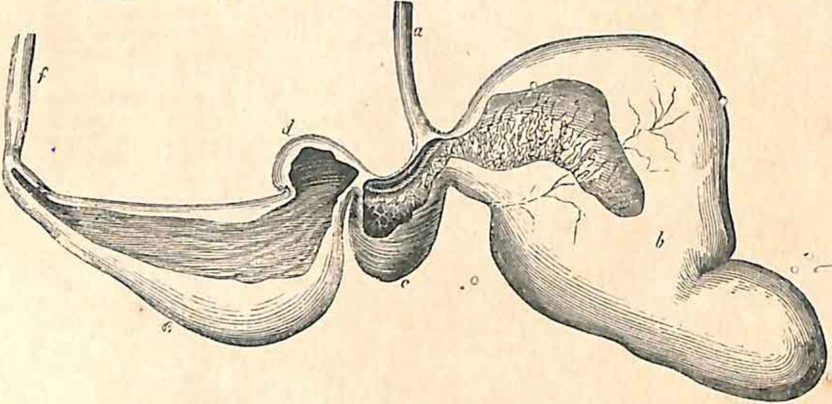


FIG. 72.—Stomach of sheep, showing the four compartments. *a*, gullet ; *b*, first stomach or paunch ; *c*, second stomach ; *d*, third stomach ; *e*, true digestive stomach ; *f*, commencement of intestine.

RECAPITULATION.—A rapid recapitulation should bring out all the points of *similarity* (feet, teeth, mouth, food, chewing cud, uses), which should be placed on the B.B. ; and then the points of *dissimilarity* (body, covering, tail, horns, beard, head), which should be placed in a parallel column.

Oral composition to follow.

An Information Lesson on the uses of the cow, sheep, and goat could well follow here.

## THE HORSE (Compared with the Donkey

### (First Lesson.)

**Things required.**—*Large pictures of the horse and the donkey, or, better still, models of both; a piece of sole leather and a piece of parchment; curry comb; specimens of horse's teeth; a horse's hoof, if possible.*

| Observations & Experiments | Remarks | Inferences |
|---|---|---|
| **HEAD.** | | |
| 1. From the pictures or models note that the *head* is long and rather broad at the top. Note the tuft of hair on top of the head. | | **As in the cow, the long head is an aid to grazing.** |
| 2. Note the *jaws*, they are very long, being about twice as long as the bones of the head. | | |
| 3. The *nose* is narrow, but the nostrils are large. | | **As the breathing is carried on through the nostrils, they want to be roomy.** |
| 4. Note the *eyes* and their position. The eyes are large. | In its wild state the horse lived on grassy plains, *i.e.*, the horse lived where it could be easily seen.<br>All children will have noticed that cart and carriage horses wear a side cover over each eye; the object is to stop the side view, so that the horse can only see straight ahead, the way the driver wishes the horse to go. | **A quick and wide sight was necessary to the horse to see its foes.** |
| 5. Note the *ears*. In the *horse* they are small and pointed; in the *donkey* they are long. | A horse is said to 'prick up its ears.' A *bad tempered* horse throws its ears back; a *frightened* horse forward. | **Both animals are quick of hearing. The ears also often show what the feelings are.** |
| 6. Children have often seen horses 'shy' or 'bolt. | | **Horses are easily frightened.** |

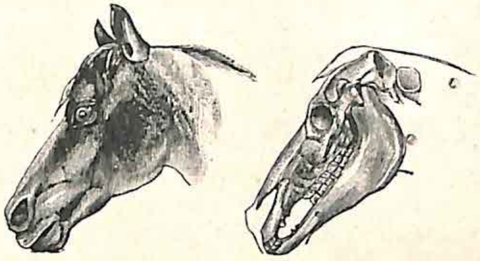


FIG. 73.—Head and mouth of horse.

| OBSERVATIONS & EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **BODY.** | | |
| 1. From model or picture note that the body of the *horse* is large and heavy, but beautiful. Note the broad chest and round hips. | | Well fitted for a beast of burden. Its heavy body denotes strength, and its broad chest lung power. |
| 2. Note its broad back sinking slightly towards the middle. | | Well fitted for riding. |
| 3. Point out a child's collar bone. Tell the class the horse has none. | No hoofed animals have them. | Only those animals have collar bones which use their fore limbs as arms. |
| 4. Note that the *neck* is long and arched. | | A grazing animal wants a long neck to reach the grass or thistles. |
| 5. Show a piece of sole leather; it is thick. | It is made from the *skin* of a horse. | The horse's skin is very thick. |
| 6. Note that the *donkey* is a smaller animal than the horse. Show pictures of Spanish or other fine breeds of asses—they are larger. Why? | | Cruelty and neglect have spoiled the despised donkey in this country. |
| 7. Show a piece of parchment. | It is made from the *skin* of a donkey. | The skin of the donkey is not so thick as that of the horse. |

| OBSERVATIONS & EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **TEETH.** | | |
| 1. Show specimens of the horse's teeth; there are cutters or biters, tearers, and grinders. | There are six sharp cutting teeth in front of each jaw, and the rest are broad and flat. | **This fits the mouth for eating grass.** |
| 2. There is a long, sharp tooth or tusk on either side of the jaw, and there is a *gap* between the tusks and the grinders, which is called the bar. This is used for the 'bit.' | Compare with our own teeth and show that we could not wear a bit. The mouth is tender. | **They were probably weapons of attack and defence in the wild state.**<br>**The bit is used for guiding the horse.** |
| 3. Horses have two sets of teeth—a milk set and a lasting set. The donkey's teeth are like those of the horse. | Compare with our own teeth. Many of our teeth decay, and we lose them as we get older. | **Some people can tell a horse's age by its teeth.** |
| 4. The lips of the horse are strong, but have a fine sense of touch. | A horse is more particular over its food than the donkey or the cow even. | **A sense of touch in the lips helps the horse to choose the right forms of food.** |
| **COVERING.** | | |
| 1. The covering of the horse is short, fine hair, which becomes thicker in winter. In the spring the coat becomes thinner, but very often it is clipped. | *Why clipped?* Refer to the glossy appearance of some coats and ask the cause. Show a curry comb, and illustrate by a reference to the habit of combing and brushing our own hair. Refer to *horse-cloths*, and ask why used. | **The horse is clipped to give its coat a nice appearance.**<br>**A horsecloth is wanted to keep the horse warm, since it has been clipped.** |
| 2. The donkey's coat is composed of thicker and coarser hair. It is rarely clipped and groomed like the horse. | | **The donkey is more hardy than the horse, and does not need a stable.** |

## THE HORSE (Compared with the Donkey).

(SECOND LESSON.)

| OBSERVS. & EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|

### MANE AND TAIL.

| | | |
|---|---|---|
| 1. The *mane* of the *horse* is long and flowing; that of the *donkey* short and upright. | Like the tail, it is sometimes cropped. The cutting and cropping is done partly for profit (sale of the horsehair) and partly for appearance. A well-combed and well-trimmed mane and tail improve the appearance of the horse very much. | **In the wild state the mane was most likely for defence; to protect the neck against the attacks of lions, &c.** |
| 2. The *tail* of the *horse* is thick, short, and pointed, and covered with long hair, which starts quite from the base of the tail. The *donkey's tail* has short hair at the root and a long tuft at the end. It is, therefore, differently made from that of the horse. | | **The horse, having short hair on its body, is troubled with flies, &c., and the long tail is wanted to drive them away; hence it should never be cropped.**<br>**The longer and coarser hair of the donkey is a better protection against flies, &c.; hence the difference in the tails.** |

### FEET AND LEGS.

| | | |
|---|---|---|
| 1. Note that the *legs* are slender but strong. | | **Slender, but strong, legs are suitable for speed.** |
| 2. Note that the top part of the *fore-legs* is short and stout. | The fore-legs correspond to our arms and are often spoken of as arms. | **They are stout to bear the weight of the large body.** |
| 3. The *fore-foot* consists of one toe. | This is the hoof, and it corresponds to the middle finger of the human hand. | **The horse and donkey move on their toes, which must be large and strong.** |
| 4. In the *hind-legs* the thigh bone has a flat bone sticking out about one-third of the way down. | The horse and the donkey, having only *one* toe on each foot, are called odd-toed. | **All odd-toed hoofed animals have this bone (process) sticking out.** |

| OBSERVS. & EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **HOOF.** | | |
| 1. Show a horse's hoof and note that the end of the toe is widened out. | | **This is to form a base for the hoof.** |
| 2. There are gristly pieces on each side, and a sole made up of fibres and fat. | | **The object of these is to increase the base.** |
| 3. The *skin* of the hoof is full of little holes or vessels, and on the outside are a number of tiny pimples or thin layers. | In these tiny pimples grows the horny matter of the hoof. There is more grows in the thick ring round the upper part of the foot, and in the cushion of the sole, than elsewhere. | **The growth of this horny matter is so arranged that as fast as the hoof is worn away from the outside it grows again from the inside.**<br>[Compare with our nails and the nails of dogs.] |
| 4. The *bottom* of the hoop is hollow, and in the middle is the 'frog.' | The hoof has no feeling, but lying beyond the horny matter of the hoof is the *quick*, which has much feeling.<br>[Compare with nail and quick of finger.] | |
| 5. Show a horse shoe. Ask its use and the reason for that use.<br>The structure of the *donkey's* legs and feet is like that of the horse. | | **The tame horse has very often to travel over hard roads; hence the need for the shoe. Wild horses keep to pasture land and therefore do not want the shoe.** |

USES.—The skin of the horse gives *leather*; with the hair from the tail cushions, sofas, chairs, &c., are *stuffed*. Horse-hair is valued for this purpose because it gives the chairs, &c., *a soft and springy action*, and does not become *lumpy* like some of the commoner kinds of stuffing. The flesh is used for *cat's-meat* (in France it is eaten); the fat for making *soap*; the hoofs give us *glue*; and the bones are burned for *charcoal*. From the skin of the donkey we get parchment, drum-ends, and leather Its milk is used for food.

## THE HORSE (Compared with the Donkey).

### (THIRD LESSON.)

COMPARATIVE SUMMARY.

| | HORSE | DONKEY |
|---|---|---|
| **Head.** | Long. | Long. |
| **Ears.** | Small. | Long. |
| **Eyes.** | Large and placed to the side. | Large, and placed to the side. |
| **Neck.** | Long and arched. | Less so in the donkey. |
| **Colour.** | More varied. | Less varied. |
| **Teeth.** | Alike. | Alike. |
| **Mouth.** | Has a 'bar.' | Has a 'bar.' |
| **Food.** | Less hardy and more dainty. | More hardy and less dainty. |
| **Covering.** | Short, fine hair. | Thicker and coarser hair. |
| **Mane.** | Long and flowing. | Short and upright. |
| **Tail.** | Covered with very long hair. | Short hair at the root and a long tuft at the end. |
| **Legs.** | Slender, but strong. | Slender, but strong. |
| **Hoof.** | Bottom hollow; sure-footed; odd-toed. | Hollow in the middle; very sure-footed; odd-toed. |

Oral composition to follow.

## THE RABBIT (Compared with the Hare).

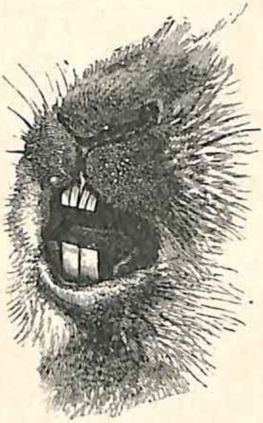
### (FIRST LESSON.)

**Things required.**—*A live tame rabbit; a fresh wild rabbit and hare from the poulterer's (live specimens are better where they can be got); rabbit's skull with teeth; a chisel and piece of soft wood; a little mould and some water.*

OUTDOOR WORK.—The teacher should encourage the children to visit the burrows of the wild rabbits, if the school is placed in a suitable district. If the children are to see the rabbits feeding they will have to pay a quiet visit early in the morning or late in the evening, when they may sometimes be seen gnawing the roots or the bark of trees. The rabbit may also be seen eating grass or the growing crops of corn; or it may be seen among the carrots, of which it is very fond. Rabbits live in colonies, so that a number of burrows will be found together. Such a collection of burrows is called a warren. If a burrow be examined it will be found to have more than one entrance or exit; this is for safety. The burrows are generally found in sandy places, or on the sides of hills. It will not be so easy to see a hare. If a 'coursing' ground is near the teacher may be able to come upon a 'form.' The hare lives in the open air, and generally picks out some spot in the middle of a field as its home. There is no digging or building, and this spot constitutes the hare's 'form.'

CLASSROOM WORK.

## TEETH.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 1. Show a rabbit's skull with the teeth, and note that the *front ones* are chisel-shaped, there being two in each jaw. Look at the two in the *top jaw* more closely, they are divided by a groove, so that each looks like two teeth. | The chisel-shaped teeth of both the hare and the rabbit grow at the roots as they wear out at the points; *i.e.* they never stop growing. Compare with the rat. | **The strong cutting teeth are for gnawing.** |
| 2. Note that there are *two other upper front teeth* close behind, which might be missed unless specially looked for; hence there are four upper and two lower front teeth. | <br>FIG. 74.—Rabbit's mouth. | |
| 3. Take the *dead hare* or a hare's skull and show the similarity of its teeth to those of the rabbit. | | |
| 4. Examine the teeth in each *upper jaw* farther back; there are six grinders in each. Compare with *lower jaw*; there are only four in each. | | **The rabbit does not bolt its food whole, but chews it.** |
| 5. Draw a *grinder* (this should have been previously loosened) and note that it has no root. | | |
| 6. Note the absence of tearing teeth. | | **The rabbit could not live on flesh.**<br>**The rabbit furnishes a good example for illustrating the statement that an animal's teeth will always tell us what its food is.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 7. Call attention to the *upper lip* of the live specimen; it is slit, and the front teeth stick out. | Everyone of these observations on the rabbit should be followed by similar observations on the hare. | **The slit in the lip, and the position of the teeth, make gnawing easy; it allows the lip to be drawn back.** |
| 8. Take a chisel and a piece of soft wood, and illustrate the *gnawing* process. | | |
| 9. Take the dead rabbit and show its *tongue*. Let the children feel it; it is hard and thick. | Compare with the cat, and contrast with the dog. | **The mouth and the tongue help to make the food fit for the stomach.** |
| 10. From the same specimen show the *roof of the mouth*; it is covered with thick, horny ridges. | Contrast with our own mouths. | |
| 11. Invite a child to gnaw a piece of wood held vertically. | It cannot do it.<br>(*a*) The child's lips are in the way. They cannot be drawn back like the rabbit's.<br>(*b*) Its teeth are not chisel-shaped.<br>(*c*) They do not stick out. | **The child's teeth are not made for gnawing.** |

## LEGS.

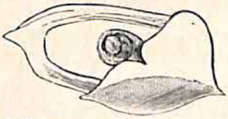
| | | |
|---|---|---|
| 1. Compare their *legs*, and note that—<br>(*a*) Those of the rabbit are long and thick.<br>(*b*) The hind legs are longer than the front ones.<br>(*c*) The hare's legs are longer than those of the rabbit. | Compare with the cat, dog, bear, and kangaroo.<br>A hunted rabbit *flies to its burrow*, whilst a hare lies close to escape notice. If seen it *runs away* and trusts to its speed and doubling. | **(*a*) The legs are made for running,**<br>**(*b*) and for jumping.**<br>**(*c*) The hare is swifter than the rabbit.** |
| 2. From the Outdoor Work the class should have noticed the jumping-like running of the rabbits. | Both have many enemies, the chief of which are weasels, stoats, cats, hawks (large), owls, ferrets, foxes, and man with gun, trap, and net. | **Both the hare and the rabbit need to be able to run very fast to get away from their foes.** |

# THE RABBIT (Compared with the Hare).

(SECOND LESSON.)

| OBSERVATIONS & EXPERIMENT. | REMARKS | INFERENCES |
|---|---|---|
| **PAWS AND CLAWS.** | | |
| 1. Note that the *fore-paws* are very strong, have sharp claws and spreading toes. | <br>FIG. 75.—Hare's foot. | **The burrows are dug out by the rabbits; hence the claws are made for scrathing.**<br>[Refer to the rabbit's habit of digging under crops to get at the young roots.] |
| 2. Count the toes; there are apparently four on each foot. But look on the inside of each *fore-foot*, and a small toe is seen, *i.e.* there are five toes. | The feet of the rabbit and the hare should be compared. | |
| 3. Look at the hind feet. There are four toes, and each toe is armed with a thick, blunt claw. | | |
| **COVERING.** | | |
| 1. Let the class see and feel the specimens. In each case the coat is fur, but the hare's is the thicker. | The rabbit makes a bed of hay, grass, and straw in its burrow, where it nurses the little rabbits, which are born without fur. The young of the *hare* is born with fur, *which enables it to share the hardy habits of its parents.* | **They require warm coats to keep them warm, and particularly the hare, which lives and sleeps in the open air.**<br>**The colour is that of their sandy homes, and is for safety, so that they cannot be seen so easily.**<br>[Compare with other cases of 'Protective Mimicry.'] |
| 2. Note the *colour* of the fur; the *rabbit's* is a sandy-grey, whilst the *hare's* is redder. | | |
| 3. Look at the tame specimen. It may be any colour—black, white, brown, grey, &c. | | |
| 4. Children who keep tame rabbits should note that they wash their fur very often. | Compare with the cat, mouse, rat, &c. | **The rabbit is a very clean animal.** |

| OBSERVATIONS & EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **TAIL.** | | |
| Observe the tail of the live rabbit; it is short and erect. Show the under part of the tail of the wild rabbit; it is white. Note that there is no white on the hare's tail. | Rabbits when running away keep their tails bobbing up and down, the white appearance making the tails look very funny. | **This probably acts as a signal to other rabbits.** |
| **WHISKERS.** | | |
| 1. Call attention to the rabbit's whiskers. Touch them, and the rabbit is aware of the fact at once. Note that the hare has whiskers. | Compare with the cat, rat, and mouse. | **The rabbit finds its way in the dark, and its whiskers help it to measure the size of its burrows.** |
| 2. Note that whiskered animals are often covered with long fur. | | **Fur keeps the animals warm and clean. Warm clothing is required for such animals.** [See 'Covering.'] |
| 3. Sprinkle some mould on the dead rabbit or hare; it brushes off easily. Then sprinkle with water; it does not cling like it does on hair. | Mud and water will not cling to fur. [Compare with the cat, rat, and mouse again.] | **Burrowing is dirty work; hence the coat is specially suited to it.** |
| **EARS.** | | |
| Note that the ears in both are long. Watch the live rabbit; its ears are movable. Note also that the ears of the hare are a little longer than those of the rabbit. Note that the hare's ears are tipped with black. | (*a*) When going into their holes rabbits lay their ears flat to their heads.<br>(*b*) Sometimes they stand up on their hind legs and move their ears about.<br>[Contrast the movable ears with ours (fixed).] | **Long ears are good for hearing. A timid, helpless animal with so many enemies wants good hearing.**<br>(*a*) **Keeps the ears out of the way.**<br>(*b*) **So that they may the more readily hear their enemies.** |

| OBSERVATIONS & EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **EYES.** | | |
| 1. Look at the live rabbit; the eyes are large and bright. | Compare the third eyelid with the little fleshy lump in the nose angle of our own eyes. | **Large, bright eyes indicate good eyesight.** |
| 2. Note that the eyes are placed one on each side of the head. | <br>FIG. 76.—Rabbit's eye. | **The rabbit needs good eyesight to see its many enemies.** |
| 3. Note that the rabbit has three eyelids, the upper and lower like ours, and a third drawn over part of the eye from the part next to the nose. | The rabbit winks with this third eyelid; perhaps 'blinks' would better explain the action to the children than 'winks.' | **The position of the eyes helps the rabbit to see all around it.** |

USES.—The *flesh* of both is eaten for *food*, and the *fur* of both is used for *clothing* (muffs, caps, to line cloaks, &c.). Both animals also afford plenty of sport (rabbiting with gun, trap, and net, and coursing hares), whilst tame rabbits are favourite pets.

## THE RABBIT (Compared with the Hare).

(THIRD LESSON.)

### COMPARATIVE SUMMARY.

| | RABBIT | HARE |
|---|---|---|
| **Size.** | Smaller than the hare. | Larger than the rabbit. |
| **Home.** | 'Burrow' and 'warren'; not a lonely animal. | 'Form'; a lonely animal. |
| **When hunted.** | Flies to its burrow. | Lies close or runs away. |
| **Young.** | Born without fur. | Born with fur. |
| **Meal times.** | Feed early in the morning or late in the evening. | Feed at night. |
| **Legs.** | Long and thick. | Longer than the rabbit's. |
| **Colour.** | Sandy grey (wild). | A redder tint. |
| **Tail.** | White on the under side. | No white on tail. |
| **Ears.** | Long. | Long and tipped with black. |
| | *General form* and *structure* alike. | |

Oral composition to follow.

# STANDARD II

## ICE.

**Things required.**—*Ice, water, candle, cork, clay; tin canister quite full of ice formed by putting tin full of water into freezing mixture; salt, medicine bottle, cork, string.*

This Lesson should be given in winter time.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Ask child to put hand on ice. | Hand becomes cold. | **Ice is cold.** |
| 2. (*a*) Compare 'colour' of ice with colours on colour card; further compare 'colour' with that of water. | The 'colour' is not found on card. | **Ice, like water, is colourless.** |
| (*b*) Make several scratches on surface of ice with penknife. Refer to appearance of ice on pond upon which skating has taken place. | Ice becomes white. | **Ice appears white when scratched.** |
| 3. (*a*) Split off thin layer of ice; hold before lighted candle; compare with glass.<br>(*b*) Hold lump of ice before lighted candle; contrast with glass. | Candle can be seen through thin layer of ice, but not through a thick lump. | **A thin layer of ice lets the light through; a thick layer does not.** |
| 4. Get child to hold piece of ice in hand. Contrast with pieces of ice lying on table. | Ice turns into water. | **Heat melts ice.** |
| 5. Place ice in water, also place cork in water. Refer to previous Lesson on floating in water (p. 16). | Both ice and cork float in water, but the ice floats deeper down in the water than the cork. | **Ice is lighter than water, but not much lighter.** |
| 6. (*a*) Take a piece of ice, force it into a lump of clay; melt ice. | The hole is not full of water. | **Water formed from ice takes up less room than the ice.** |
| (*b*) Previous to lesson freeze some water in an open tin canister in accordance with directions in 7; introduce the canister *full of ice* to class; melt ice. | The can is not full of water. | |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 7. Prepare a freezing mixture by mixing equal parts of pounded ice and salt. Let child feel the freezing mixture. Insert tightly corked bottle full of water into mixture, allow it to remain about a quarter of an hour. The cork should be tied down with string. *Compare with bursting of pipes in frosty weather.* | Water has turned to ice and bottle has broken. | **Cold causes water to turn into ice, which takes up more room than water.** |

B.B. SKETCH.

Ice.

| | |
|---|---|
| **Cold.** | **Lighter than water.** |
| **Colourless.** | **Takes up more room than water.** |
| **Melts with heat.** | |

A Conversation Lesson on Winter might follow.

## BOILING WATER AND STEAM.

**Things required.**—*Water, two flasks, soaked bran, or solid blue litmus; cork to fit one of flasks; kettle, piece of slate, string.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Take flask of water containing soaked bran or solid blue litmus; apply heat; note currents; draw diagram on B.B. | | **When water is heated, the drops of heated water rise through the middle of the water and pass down the sides.** |
| (*b*) Recapitulate par. 5, Water, page 17, Standard I. | The bubbles form, rise, and burst, at first at some distance from the surface, afterwards on the surface itself. | **When the bubbles rise to the surface the water boils.** |
| 2. (*a*) Place a few drops of water in an evaporating dish; heat.<br>(*b*) Draw attention to the great 'cloud' issuing from the flask of boiling water. | Water is changed into 'steam.' | **Water when heated becomes steam, which takes up much more room than water.** |

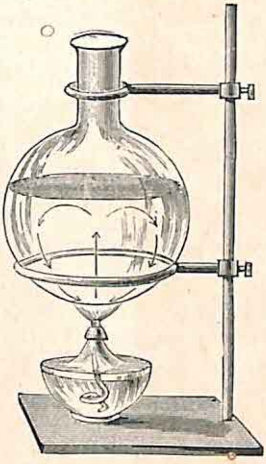


FIG. 77.—Experiment illustrating motion of heated water.

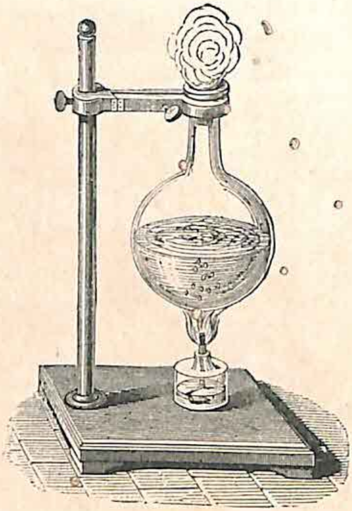


FIG. 78.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. Insert cork *lightly* into neck of flask of water that is about to boil. Speak about the great power of steam. | Cork is driven out of flask. | **Steam has great force** |
| 4. (*a*) Ask if anything can be seen between the boiling water and the 'cloud' issuing from top of flask.<br>(*b*) Draw attention to the apparently empty space between the spout of kettle and the 'cloud of steam.'<br>(Argue from 3 and 4 (*a*) that it was just in that apparently empty space that the work of driving out the cork was done.) | Nothing can be seen. | **Real steam is invisible.** |
| 5. (*a*) Place hand in 'cloud' issuing from top of flask, taking care to keep hand some distance from top of flask. | Hand becomes moist. | **What we call 'steam' is really steam changing back into water.** |
| (*b*) Place hand a short time quite near top of flask. (A timely warning should be given here.) | Hand becomes very red and hot. | **Steam scalds. A scald is dangerous.** |

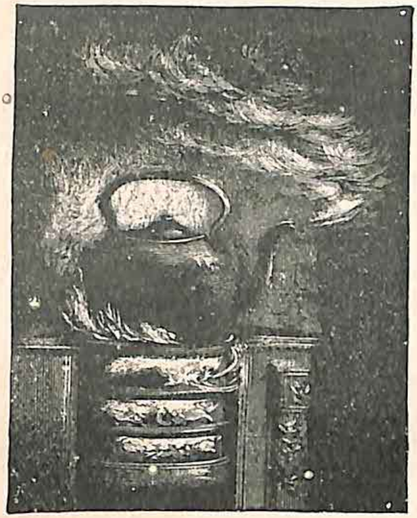


FIG. 79.—Boiling kettle.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 6. (*a*) Insert piece of cold slate into the apparently empty space between spout of kettle and cloud of 'steam.'<br>(*b*) Lower small piece of slate into neck of flask containing boiling water, taking care to keep slate out of water. | Slate becomes covered with water. | **Steam when cooled becomes water.** |

B.B. SKETCH.

**Boiling Water.**

**When water is being heated, the drops of hot water move through the water.**

**Water when heated becomes steam.**

**Steam.**

**Has great force.**
**Is invisible.**
**Scalds We should not go near steam.**
**When cooled becomes water.**

## HARD AND SOFT BODIES.

**Things required.**—*Sponge, soap, wax, clay, chalk, lead, wood, copper, iron (nails, hammer), steel (penknife), glass.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Have the specimens mentioned in the next column arranged indiscriminately on the table. Let a couple of children separate the specimens into two heaps, one containing those that can, the other those that cannot be squeezed by the hand. | Sponge, soap, wax, clay can be squeezed by the hand; lead, wood, copper, iron, steel, glass cannot be squeezed by the hand. | **Sponge, soap, wax, clay are soft bodies; lead, wood, copper, iron, steel, glass are hard bodies.** |
| 2. Mix the specimens once more; let the children classify them into those that can, and those that cannot be scratched by the finger-nail. | Sponge, soap, wax, clay, lead, wood can be scratched; copper, iron, steel, glass cannot be scratched by the finger-nail. | **Sponge, soap, wax, clay, lead, wood are soft bodies; copper, iron, steel, glass are hard bodies.** |
| 3. Once more mix the specimens, and this time classify them according as they can, or cannot be scratched by a knife. | Sponge, soap, wax, clay, lead, wood, copper, iron can be scratched by knife; glass cannot be scratched. | **Sponge, soap, wax, clay, lead, wood, copper, iron are softer than steel; glass is harder.** |
| 4. Draw attention to the three lists, and compare. | Lead, wood, copper, iron are called both hard and soft. | **Some things which are hard when compared with certain things, are soft when compared with other things.** |
| 5. The fact that scratching has been used as a test for hardness should now be dwelt on, and the children led to see that this test may be used as a means of arranging the specimens on the table in the order of hardness.<br>(Experiment 3 should be worked again.) | The steel does not scratch the glass, but does scratch all the other specimens. | **Glass is the hardest thing on the table; steel is the next hardest.** |
| 6. Apply the scratching test to the other specimens. | Iron scratches copper, copper scratches wood, &c. | **Bodies arranged according to degree of hardness:—<br>1. Glass. 6. Lead.<br>2. Steel. 7. Chalk.<br>3. Iron. 8. Wax.<br>4. Copper. 9. Clay.<br>5. Wood. 10. Soap.<br>11. Sponge.** |

B.B. SKETCH.

| | | | |
|---|---|---|---|
| Nail scratches (Soft.) | Sponge. | Squeezed. (Soft.) | Scratched by knife. |
| | Soap. | | |
| | Wax. | | |
| | Clay. | | |
| | Lead. | Not squeezed. (Hard.) | |
| | Wood. | | |
| Nail does not scratch . . (Hard.) | Copper. | | |
| | Iron. | | |
| | Steel. | | |
| | Glass. | . . . . . . . | Not scratched. |

Order of hardness.

1. Glass.
2. Steel.
3. Iron
4. Copper.
5. Wood.*
6. Lead.
7. Chalk.
8. Wax.*
9. Clay.*
10. Soap.*
11. Sponge.

## THINGS THAT BEND AND STRETCH.

**Things required.**—*A piece of elastic, india-rubber tubing, flat ruler, spirit-lamp, cane, string; a willow wand or any convenient substitute; wood for arrow, solid india-rubber ball, clay, slates, chalk, carving knife; long and short pieces of glass tubing; old pair of side-spring boots.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Take a piece of ordinary elastic, measure its length; stretch it slightly, measure again; remove stretching force, measure a third time.<br>(*b*) Repeat with a piece of india-rubber tubing. | The elastic is easily stretched, and when let go resumes its former length.<br>Same results. | **The elastic is much like the india-rubber tubing.** |
| 2. (*a*) Examine piece of elastic; remove cotton covering; expose the elastic threads; take a thread and treat as in 1 (*a*).<br>(*b*) Burn a piece of the elastic thread and a piece of india-rubber tubing in flame. | Same results.<br>Both take fire and give out a peculiar smell. | **The piece of elastic is made up of threads of india-rubber covered with cotton.** |

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* The precise order of these will vary somewhat in different specimens.

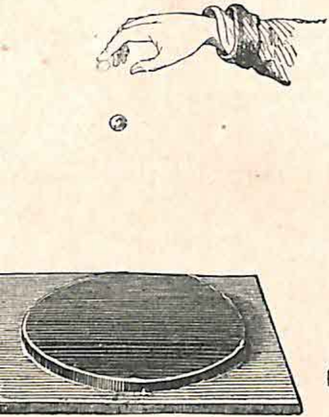

FIG. 80.

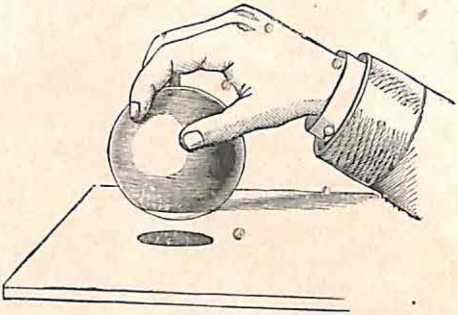

FIG. 81.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. (*a*) Take cane, bend it, let go. | The cane easily alters its shape, and resumes its former shape when the hands are removed. | **Cane is like elastic.** |
| (*b*) Make a bow by tying string to ends of cane; shoot an arrow.<br>(*c*) Repeat with suitable piece of wood. | The cane, in trying to become straight, forces out the arrow. | **Cane and wood are useful for making bows because they are elastic.** |
| 4. (*a*) Press solid india-rubber ball on table. | The part nearest the table is pressed flat. | |
| (*b*) Allow a round ball of clay to fall on table. | The side that touches the table becomes flattened; the clay remains on the table. | **The ball when it strikes the slate becomes flattened, but because the india-rubber is elastic, the ball quickly becomes round again, and in doing so bounces off the slate.** |
| (*c*) Allow india-rubber ball to fall on table. | The ball bounces off the table. | |
| (*d*) Cover a slate with chalk, place india-rubber ball carefully upon it; remove ball, examine (fig. 81). | Only a very small part of the ball has any chalk upon it. | |
| (*e*) Drop same ball from a height on to slate; examine ball. | A much larger part of the ball has chalk upon it. | |
| . Drop a marble on the table (fig. 80). | It bounces. | **The marble must be elastic.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 6. Try to bend blade of carving knife by pressing its point on table; remove from table. | The steel bends and regains its former shape. | **Steel is elastic.** |
| 7. (*a*) Show a chair spring, spring of a bicycle seat, spring from a mechanical toy; press each, remove pressure.<br>(*b*) Show clock spring, watch spring, &c. | They bend and regain their shape. | **Steel is useful for making different kinds of springs because it is elastic.** |
| 8. (*a*) Try to bend a short piece of glass tubing. | It bends and breaks. | **Even glass is elastic.** |
| (*b*) *Gently* bend a long piece of glass tubing. | It bends a little way and will take up its former shape. | |
| 9. (*a*) Take a piece of elastic and stretch it very hard for some time.<br>(*b*) Show an old pair of side-spring boots. | It does not return to its former shape. | **Too much power destroys the elastic force in things.** |
| (*c*) Bend cane, steel spring, &c., as much as possible. | They break. | |

B.B. SKETCH.

**Elastic Things.**

**India-rubber—useful for balls, tubing.**
**Wood—useful for bows.**
**Steel—useful for springs.**
**Even glass and marbles are elastic.**

## THINGS SOLUBLE AND INSOLUBLE IN WATER.

**Things required.**—*Sugar, salt, blue-stone (copper sulphate), or any other soluble coloured solid; chalk, sand, mould, water, test tubes or tumblers, or beakers; flower-pot containing charcoal; sand or any other filtering medium; blotting paper, glass funnel, alum, pebbles, and string.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Get children to try to dissolve sugar, salt, chalk, sand in water. | Sugar and salt disappear in water; chalk and sand do not. | **Sugar and salt dissolve in water; chalk and sand do not.**<br>[Teach the terms soluble and insoluble.] |
| (*b*) Dissolve a little 'blue-stone' in warm water. Repeat with some other colouring matter. | None of the solid remains; all the water is blue. | **Some soluble solids colour water.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 2. (*a*) Stir up mixture of sand and water; cease stirring.<br>(*b*) Note length of time required for the settling process; recall Lesson on Sand (p. 6), when muddy water was made clear by running it through sand. | Sand begins to fall to bottom of vessel. | Sand may be separated from water by allowing the sand to 'settle.' |
| (*c*) Run sand and water through prepared flower-pot. | Water runs through clearer. | Sand can be separated from water by filtering the mixture of sand and water. |
| (*d*) Take piece of blotting paper, cut into a circle (fig. 82, No. 1); fold into semicircle (No. 2); fold again into a quadrant and open as shown in No. 3. Place in funnel, moisten a little to cause paper to adhere to sides. Pour in sand and water (fig. 83). | The sand remains on the blotting paper, the water runs through clear. | The blotting paper must have a number of holes which are smaller than the grains of sand. |
| (*e*) Repeat with chalk and water, and mould and water. | | Insoluble solids can be separated from water by filtering. |

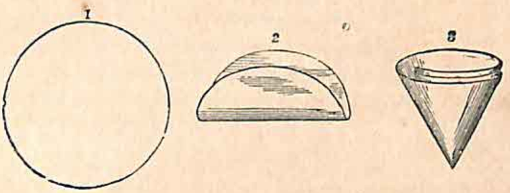

FIG. 82.—Showing how the filter is to be folded.

| | | |
|---|---|---|
| 3. (*a*) Try to filter the solution of sugar, salt, or blue-stone. | The liquid runs through without change. Nothing is left on the paper. | Solids in solution cannot be separated from water by filtering. |
| Recall par. 7, Lesson on Water (p. 17) and repeat experiment. Repeat with sugar, blue-stone, &c. | Salt, sugar, &c., are left behind. | But they can be separated:—<br>1. By boiling off the water. Evaporation. |
| (*c*) Dissolve as much alum, blue-stone, and sugar as possible in separate portions of hot water. Suspend pebbles by threads in solutions. Put aside for a few days. | Bright shining little things (crystals) cling to the pebbles and threads (figs. 84, 85). | 2. By gradually cooling a solution containing a great deal of the solid dissolved in it. |

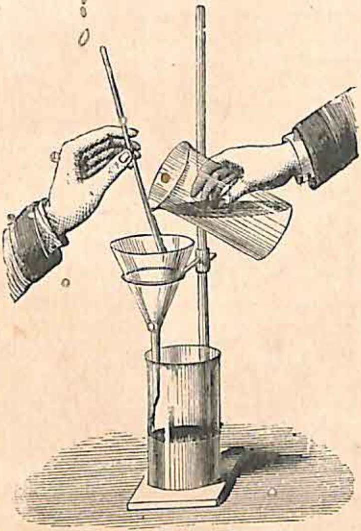

FIG. 83.—Apparatus for filtration.

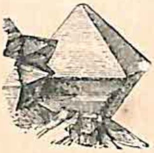

FIG. 84.—Crystals of alum.

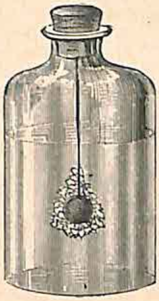

FIG. 85.—Showing the manner of preparing a group of crystals.

B.B. SKETCH.

| **Soluble in water.** | **Insoluble in water.** |
|---|---|
| **Sugar.** | **Sand.** |
| **Salt.** | **Chalk.** |
| **Blue-stone.** | **Mould.*** |

**To get insoluble things from water—Filter the water.**
**To get soluble things from water—1. Evaporate the water.**
**2. Make crystals.**

## SODA.

**Things required** – *Some ordinary washing soda, preferably a piece for each child; a saturated solution of soda in which a stone has been suspended and which has been allowed to cool slowly; water, spirit-lamp, greasy bottle.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Let children taste a small piece of the specimen before them. | It has a rough, unpleasant taste. | **The thing before them is soda.** |
| 2. Put a little powdered soda into water; stir. | The soda disappears. | **Soda is soluble in water.** |
| 3. Let child feel the water with soda dissolved in it. | It has a peculiar 'soapy' feel. | **The soda changes the water somewhat.** |

---

* In reality a small proportion of mould is soluble in water, but this need not be noticed here.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 4. (*a*) Pour powdered soda into water till no more will dissolve even after constant stirring. | | |
| (*b*) Heat the water. | More soda now dissolves. | Hot water dissolves more soda than cold water. |
| 5. (*a*) Make a hot saturated solution, suspend a stone in it, put it aside, allow it to cool slowly; examine next day.<br>(*b*) Introduce previously prepared solution with stone in it; remove stone; examine what is round it; break off a piece; let child taste. | The stone has round it a number of pointed bodies of the same shape but of different sizes. They have a rough, unpleasant taste. | The soda has been made into soda crystals.* |
| 6. (*a*) Try to wash greasy bottle with water. | The grease is not washed away. | |
| (*b*) Wash greasy bottle with soda-water. | The grease is washed away. | Soda-water will dissolve fats.† |

### B.B. SKETCH.

**Soda.**

Peculiar taste.
Soluble in water.
Hot water dissolves more soda than cold.
Can be made into crystals.
Soda-water dissolves fats.

## POROUS BODIES.

**Things required.**—*Water, coloured water* (*red ink will do*), *sponge, bread, brick, saucers, blotting paper, filter glasses, highly glazed paper, muddy water, piece of cane, paraffin, lamp wick, spirit-lamp, chalk, sugar.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Show sponge, bread, brick, chalk, sugar. Ask child to separate them into those that have holes and those that have not. | The holes can be seen in sponge, bread and brick, they cannot be seen in chalk and sugar. | |
| (*b*) Place sponge under water; squeeze sponge while still under water. | Bubbles of air rise to the surface of the water. | The holes in a dry sponge contain air. |

---

* The children might be encouraged to repeat this experiment at home. The teacher might also make some alum crystals—as in Lesson, 'Things Soluble and Insoluble in Water.'

† Some of the common uses of soda might be asked for.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 2. (*a*) Place dry sponge in a saucer containing a little water.<br>(*b*) Repeat with bread. | The water is sucked up. | The holes in the sponge and bread can hold water. |
| 3. (*a*) Make a filter of blotting paper and also one of highly glazed paper. (See Lesson on 'Things Soluble and Insoluble in Water,' 2 (*d*).) Pour muddy water on the blotting paper. | The water runs clear through the blotting paper; the mud is left behind. | The holes in the blotting paper are larger than the drops which make up the water, but smaller than the grains of dirt. |
| (*b*) Pour muddy water on the glazed paper.<br>(*c*) Allow the water to remain some time on the glazed paper. | The water does not run through at first, but does afterwards. | The holes in the glazed paper are filled up with something which the water dissolves out. |
| 4. Try to 'blot' spots of ink, one with blotting paper, another with glazed paper. | The blotting paper sucks up the ink; the glazed paper does not. | The blotting paper sucks up the ink into its small holes; the glazed paper cannot do this because its holes are already filled up. |
| 5. (*a*) Try to ignite a piece of cane with a match. | It burns with difficulty. | |
| (*b*) Place one end of cane in a saucer containing paraffin; apply light to the other end. | The cane burns much more easily. | The paraffin is sucked up through the little holes in the cane. |
| (*c*) Examine the cane. | Is has a number of little holes, and the top which has been burning smells of paraffin. | |
| 6. (*a*) Try to ignite a piece of dry lamp wick. | It burns with difficulty. | The wick must have a number of little holes through which the spirit is sucked up. |
| (*b*) Place lamp wick in spirit-lamp; ignite.<br>Compare with candle wick. | It burns easily. | |
| 7. Place pieces of chalk and loaf-sugar side by side into saucer containing a little red ink or coloured water.<br>(The term *porous* might now be taught.) | Both the chalk and the loaf sugar suck up the liquid. | The chalk and loaf sugar must contain little holes. |

B.B. SKETCH.

Things in which we can see holes.

Sponge,
Bread, } suck up water through holes.
Brick,

Things in which we cannot see holes.

Chalk,
Sugar, } suck up water; then must have holes.

Porous Bodies.

Sponge, bread, brick, chalk, sugar, cane, lamp-wick, candle-wick.

## THE SPIRIT USED IN THE SPIRIT-LAMP.

**Things required.**—*Spirit, various glass flasks and beakers, colouring matter (red ink will do), evaporating dish, scales, camphor, any varnish or hektograph ink; a thermometer (for teacher's use only) would be advantageous, but is not absolutely necessary.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Ask children to look at two flasks, one containing water, the other spirit from spirit-lamp.<br>(*b*) Let child smell each.<br>(*c*) Let child taste each. | They both *look* alike.<br>Spirit has a distinct smell and taste; water has none. | **Spirit, like water, is colourless; but it is not water, for it has a peculiar smell and taste.** |
| 2. Pour spirit from one vessel into another. Note results. | Spirit pours out easily, takes the shape of the vessel into which it is poured, has a flat top. | **Spirit is like water, for it pours out, takes up shape of vessel, and has a flat top.** |
| 3. (*a*) Pour water into long glass vessel; carefully pour a little coloured spirit on the water (fig. 86).<br>(*b*) Weigh small flask full of water and same flask full of spirit.<br> <br>FIG. 86.—Coloured alcohol floating on water | The spirit floats on top.<br>Second weight is a little lighter than first. | **Spirit is lighter than water** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 4. (*a*) Place a little spirit in evaporating dish; apply light.<br>(*b*) Light spirit-lamp.<br>(*c*) Light candle. Compare light and heat given from spirit-lamp and candle. Hold piece of cardboard in flame of each. | Spirit takes fire easily, burns with a pale flame, which gives very little light but much heat, and does not blacken the cardboard. | **The spirit-lamp is very useful in experiments because it gives much heat and does not make things black.** |
| 5. Wet back of one hand of child with water, and back of other hand with spirit; tell him to wave both in air. | The hand wetted with spirit becomes dry sooner than the other. | **Spirit disappears into the air sooner than water.** |
| 6. (*a*) Try to dissolve camphor first in water then in spirit. | Camphor does not dissolve in water, but does dissolve in spirit. | **Spirit is useful for dissolving many things that do not dissolve in water.** |
| (*b*) Smear boy's hand with varnish or hektograph ink; let him rub hand first with water then with spirit. | The water does not remove the stain, but the spirit does. | |
| 7. Heat some water until it is quite hot (above 78° C. or 173° F.), but not boiling.<br>Place test-tube containing spirit in hot water (fig. 87). | Spirit boils; water does not. | **Spirit when it boils is not so hot as water.** |

## B.B. SKETCH.

Spirit.

Like water.
1. Colourless.
2. Pours out.
3. Takes up shape of vessel.
4. Has a flat top.
5. Boils.
6. Disappears in air.

Unlike water.
1. Has distinct taste and smell.
2. Lighter than water.
3. Burns.
4. Dissolves things that water will not dissolve.
5. Boils sooner than water.
6. Disappears in air sooner than water.

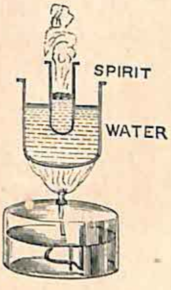

FIG. 87.

## PARAFFIN OIL.

**Things required.**—*Some paraffin oil, various vessels, spirit-lamp, paraffin lamp, matches, paper, any colouring matter, water.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Show bottle containing paraffin without giving name of liquid; notice colour; pour it from bottle into saucer. | What is in the bottle is colourless, pours out easily, has a flat surface. | **What is in the bottle is like water.** |
| 2. (*a*) Let child smell liquid and taste a drop of it. | It has a peculiar smell and disagreeable taste. | **It is not water, but paraffin oil.** |
| (*b*) Pour a little of the liquid into lamp; light lamp. | The lamp burns brightly. | |
| 3. Pour a little *cold* paraffin into a dish; quickly plunge a lighted match into it. | The match goes out. | **Paraffin oil itself will not burn.** |
| 4. (*a*) Drop a little water on one piece of paper, a little paraffin on another piece; wave in air. | The paper with the paraffin upon it gets dry sooner than the paper with the water upon it. | **Paraffin disappears in the air sooner than water.** |
| (*b*) Pour a few drops of water into the palm of one hand of a child and a little paraffin into the other. | The hand containing the paraffin gets dry first. | **The paraffin is turned into a gas.** |
| 5. *Gently* warm a *little* paraffin; hold lighted match a short distance above liquid. (Contrast with 3.) | The paraffin takes fire. | **The gas given off by paraffin burns.*** |
| 6. Colour a little water, pour into glass; *gently* pour some paraffin on top of water. | The paraffin floats on top. | **Paraffin is lighter than water.** |

### B.B. SKETCH.

Paraffin.

| | | | |
|---|---|---|---|
| Colourless,<br>Pours out,<br>Has flat top, | like water. | Strong smell and taste,<br>The gas from it burns,<br>Is lighter than water, | unlike water. |

---

* The danger of pouring out paraffin near a fire or lighted candle, of allowing the reservoir of a lamp to get hot, &c., may here be dwelt upon.

## QUICKSILVER.

**Things required.**—*Some quicksilver; two or more beakers or small bottles; bright silver coin; lead, iron spoon, slate, water, test-tubes, tinfoil, scales.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Show quicksilver; compare with colour of silver. | It is bright like silver. | **Quicksilver is so called because it looks something like silver, and because it moves about as though it were quick, or alive.** |
| (*b*) Let a drop of quicksilver fall on slate; slightly tilt slate. | The drop 'runs about' over the slate. | |
| 2. (*a*) Let a drop of quicksilver fall into water. | It sinks to the bottom. | **Quicksilver is much heavier than water.** |
| (*b*) Weigh a small bottle full of water; weigh the same bottle full of quicksilver. | The second weight is much greater than the first. | |
| 3. Let child put finger into quicksilver. | Finger feels cold. | **Quicksilver feels cold to the touch.** |
| 4. (*a*) Melt lead in spoon; compare with quicksilver. | Quicksilver is something like melted lead. | **Quicksilver is something like lead and silver, for:—**<br>**1. It is heavy.**<br>**2. It is bright.**<br>**3. It is cold to the touch.** |
| (*b*) Compare quicksilver with lead and silver as regards weight, bright surface, &c. | It is also something like lead, silver, &c. | |
| 5. (*a*) Pour quicksilver from one bottle into another; note surface of quicksilver. | It pours easily from one vessel into another; takes up the shape of the vessels; has a level top. | **Quicksilver is like water, for:—**<br>**1. It pours out easily.**<br>**2. It takes up the shape of the vessel into which it is poured.**<br>**3. It has a flat top.**<br>**4. It boils.**<br>**5. It becomes a vapour.**<br>**6. The vapour can be made into quicksilver by cooling.**<br>**7. It dissolves solids.** |
| (*b*) Drop a little on slate. | The drops are round | |
| (*c*) Heat a little quicksilver in a test-tube. | The quicksilver boils, becomes a vapour, and is brought back to quicksilver in the cool part of the tube. | |
| (*d*) i. Put a small piece of tinfoil* in quicksilver; shake; try to find tinfoil. | The tinfoil has dissolved. | |
| ii. Tie a piece of tinfoil* over mouth of test-tube; gently pour a drop of quicksilver on tinfoil; allow to stand for a few minutes. | The drop of quicksilver eats its way through the tinfoil and falls into the tube. | |

---

* The 'lead-foil' in which tobacco is often wrapped will answer the purpose admirably.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 6. (*a*) Ask child to dip finger into quicksilver and note whether finger becomes damp.<br>(*b*) Ask child to examine bottle after quicksilver has been poured out of it. | The finger is quite dry on removal from quicksilver.<br>The bottle is not wet. | **Quicksilver is unlike water because it does not wet the finger or glass.** |

B.B. SKETCH.

Quicksilver.

| Like lead and silver. | Like water. |
|---|---|
| 1. Heavy. | 1. Pours out. |
| 2. Bright. | 2. Takes up any shape. |
| 3. Cold. | 3. Has flat top |
| | 4 Boils. |
| | 5 Dissolves things. |

Unlike water

Does not wet finger or glass.

## A GLASS BOTTLE.

**Things required.**—*Glass bottles and flasks of various shapes; water, colouring matter, candle; corked bottle which has held aqua fortis (nitric acid) for some time; glass tubing, spirit-lamp or bunsen flame, blowpipe.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Pour coloured water into bottle.<br>(*b*) Lower lighted candle into bottle. | The coloured liquid and the lighted candle can be seen in the bottle. | **We can see through glass.**<br>**Glass lets light through. It is transparent.** |
| 2. Again draw attention to water in bottle. | The bottle holds the water easily; none of it runs out. | **A bottle is useful for holding liquids.** |
| 3. Try to scratch glass with slate pencil. | The slate pencil does not scratch glass. | **Glass is hard.** |
| 4. Recall some of the Experiments that have been worked in which sugar, salt, soda, &c., have been dissolved in water. Ask if they have ever found the test-tube or beaker dissolve. | The glass test-tube, &c., has not dissolved. | **Water will not dissolve glass.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 5. (*a*) Show bottle containing nitric acid. Draw attention to bottle and cork. | The cork has been partly eaten away; no change has taken place in the bottle. | **Bottles are made of glass because it is not dissolved or eaten away by liquids.** |
| (*b*) Pour two or three drops of the acid into a tumbler of water. Let child taste. | The water tastes sour — something like vinegar. | |
| 6. Drop small medicine bottle on ground. | It breaks. | **Glass is brittle.** |
| 7. Hold piece of glass tubing in flame of spirit-lamp.<br>When the flame becomes yellow— | | **Glass can be softened by heat, and made into any required shape.** |
| (*a*) Try to bend glass. | The glass bends easily. | [If means do not exist for working the next Experiment, infer that the bottle was made into its shape when the glass was soft.] |
| (*b*) Try to make it longer. | It easily pulls out into a long thread. | |
| 8. (*a*) By means of blowpipe direct bunsen flame on end of piece of glass tubing, and thus close end of tube (fig. 88). | | **The bottle was made by softening glass and then blowing into it.** |
| (*b*) Place closed end in blowpipe flame, and when glass is red hot get a first class boy to blow down the tube. | The end of the glass is blown out into a round bulb. | |

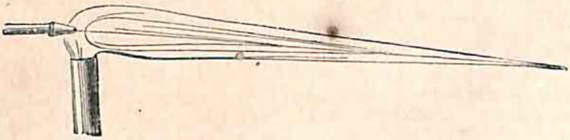

FIG. 88.—The blowpipe flame

B.B. SKETCH.

**Glass Bottle.**

**Transparent.**
**Useful for holding liquids because it will not dissolve.**
**Brittle.**
**Made by softening glass and blowing into it**

## A GLASS OF SEA WATER.

**Thing required.** —*Sea water or a strong solution of salt and water; evaporating dish, spirit-lamp, scales, fresh water, colouring matter (red ink will do), retort, condenser (a kettle and indiarubber tubing leading from spout to bottle will do), ink.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Ask child to taste sea water. | Water tastes salt. | **Sea water has salt dissolved in it.** |
| (*b*) Evaporate a little in dish. | Salt is left behind. | |
| 2. (*a*) Weigh flask full of sea water; then same flask full of fresh water. | Second weight lighter than first. | **Salt water is heavier than fresh water.** |
| (*b*) Pour sea water into long glass vessel; colour fresh water, carefully pour into vessel. | Fresh water floats on top. | |
| 3. (*a*) Place new laid egg in fresh water. | Egg sinks in fresh water. | **Salt water presses upwards with greater force (is more buoyant) than fresh water.** |
| (*b*) Place same new laid egg in sea water. [This experiment should be carefully rehearsed before the lesson, and the water made more or less salt until the desired result is obtained.] | Egg floats in salt water. | |
| (*c*) Float a piece of wood in fresh and salt water. | More of the wood floats out of the salt water than out of the fresh. | |
| (*d*) Recall experiments showing upward pressure of water. (Standard I., Water, Second Lesson, p. 16.) | | |
| 4. (*a*) Ask children to describe how they have seen the salt obtained from salt water. | | |
| (*b*) Now say that we wish to get the *water* and not the salt. Recall experiment of placing slate in steam of kettle. Introduce retort and condenser (fig. 89); arrange as in diagram. After quarter of an hour examine retort and condenser. | Pure water is found in condenser; salt in the retort. | **Pure water can be obtained from salt water by boiling the water, catching the steam and turning it back into water.** |
| (*c*) A very striking variation can be made by pouring ink into the retort. | | |

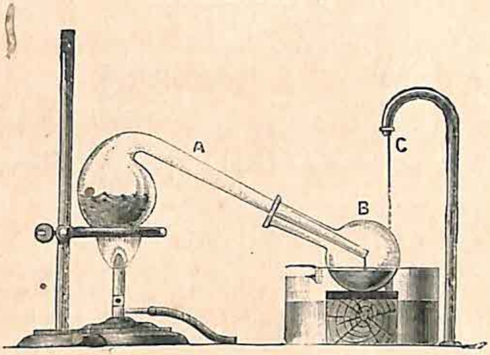

FIG. 89.

B.B. SKETCH.

**Sea Water**

**Contains salt.**
**Heavier than fresh water.**
**More buoyant than fresh water.**
**To get pure water from sea water :—**
**(*a*) Boil water.**
**(*b*) Cool the steam and thus turn it into water.**

## SOLIDS AND LIQUIDS.

**Things required**.—*Sugar, chalk, brick, coal, lead, iron, ice, water, spirit, quicksilver, spoon, spirit-lamp.*

(The numbers of the paragraphs correspond to the numbers in the B.B. Sketch.)

1. Have the above specimens arranged indiscriminately on table. Let child separate them into two classes—those than can be and those that cannot be taken up in a lump in the hand. Write out lists and put characteristics below as in B.B. Sketch.

2. Again mix the specimens, and next have them arranged into those into which a child can thrust his finger and those into which he cannot thrust his finger. Note that the objects fall into the same columns as before.

3. Next classify specimens into those that will pour and those that will not pour out.

4. Drop each on floor, and note those that do and those that do not keep their shape.

5. Lastly, note the difference in the top of each, and classify into those that must have and those that need not have a flat top.

6. Introduce the terms *solid* and *liquid*, and with help of class draw up short definitions of solids and liquids.

7. Heat ice and lead and note the results. Try also with chalk, piece of brick, &c.

B.B. SKETCH.

| | |
|---|---|
| Sugar, Lead,<br>Chalk, Iron,<br>Brick, Ice,<br>Coal, | Water,<br>Spirit,<br>Quicksilver, |
| 1. *Can be taken up in a lump in the hand. | 1 Cannot be taken up in a lump in the hand. |
| 2. Finger cannot be pushed into these. | 2. Finger can be pushed into these. |
| 3. Will not pour out | 3. Will pour out. |
| 4. Keep shape | 4 Do not keep shape. |
| 5. Need not have flat tops | 5. Have flat tops |
| Solids. | Liquids. |

6. Solids keep their shape, do not pour out, and need not have flat tops. Liquids do not keep their shape, do pour out, and always have flat tops.
7. Some solids when heated become liquids.

## THINGS THAT MELT.

**Things required.**—*Ice, butter, tallow, sealing-wax, glass rod, lead, iron spoon, candle, fire, lamp or gas flame, test-tubes, poker.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Ask child to hold small piece of ice in palm of hand. | The ice turns to water. | **The heat of the hand is enough to turn solid ice into liquid water.** |
| 2. (*a*) Ask child to hold piece of butter in palm of hand.<br>(*b*) Repeat with tallow.<br>(*c*) Place tallow and butter before fire, but some distance away from it. | The butter melts very slowly, if at all.<br>The tallow does not melt.<br>They melt easily. | **The heat of the hand is hardly enough to melt butter, and not enough to melt tallow; greater heat is required** |
| 3. Pour the melted tallow or butter from one vessel into another. | It pours out easily. | **The heat has turned the solid butter into liquid butter or oil.** |
| 4. Place the melted tallow or butter in some place where it can cool. | It becomes solid again. | **Cold causes the liquid butter to become solid butter.** |
| 5. Place sealing-wax in same position as to fire as butter in 2 (*c*). | The sealing-wax does not melt. | **The heat that is enough to melt butter is not enough to melt sealing-wax.** |
| 6. (*a*) Place end of stick of sealing-wax in flame of lighted candle.<br>(*b*) Place piece of lead in iron spoon over lighted candle. | The sealing-wax melts easily, and falls as drops.<br>The lead melts very slowly, if at all. | **More heat is required to melt lead than to melt sealing-wax.** |

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* As this B.B. Sketch is very long, points 1 to 5 need not be written on B.B.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 7. (*a*) Place piece of lead in test-tube; heat in lamp or gas flame; pour out lead.<br>(*b*) Place piece of glass tubing in gas flame; when the flame becomes yellow try to bend glass. | The lead melts; the glass does not.<br>The heated glass bends easily. | **The heat that is enough to melt lead is only enough to make glass soft.** |
| 8. (*a*) Place piece of lead in iron spoon; heat until lead melts.<br>(*b*) Try to bend iron spoon. | The lead melts; the spoon cannot be bent. | **Heat that is enough to melt lead and to soften glass is not enough to even soften iron.** |
| 9. Place poker in fire till it is red hot; try to bend it. | The red hot poker is bent. | **The heat of the fire softens iron; greater heat would make it melt.** |

B.B. SKETCH.

**Ice melts in hand.**
**Butter melts before fire.**
**Lead melts in gas flame.**
**Glass softens in gas flame.**
**Iron softens in the fire.**

**Some things require more heat to melt them than others.**

**Many solids when heated turn to liquids.**

## EFFECTS OF HEAT ON THE SIZE OF IRON, WATER, AND AIR.

**Things required.**—1. (*a*) *Get an iron ball; bend a piece of stout copper wire into a circle which is just large enough to allow the ball to pass through it. An elaborate form of the apparatus is shown in fig.* 90 *; or,*

(*b*) *Get a cylindrical piece of iron* (*a piece of iron paling will answer admirably*). *Carefully cut a hole in a piece of sheet zinc just large enough to allow the paling, when stood on end, to pass through it.*

2. *A flask filled with coloured water and provided with a well-fitting cork through which runs a narrow tube* (*fig.* 91). *The scale is unnecessary.*

3. *A bladder, cotton, spirit-lamp, fire, flask, water, tongs.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Try to rest iron ball on circle of copper wire. | The ball falls through the circle. | **The ball is smaller than the circle.** |
| 2. Heat ball in fire; remove with tongs; once more place on circle. | The ball does not fall through. | **The ball is now larger than the circle.**<br>**Heat makes iron swell.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. Plunge the ball into water. Let child feel the ball. Place once more on circle. | The ball feels cold, and passes through the circle. | **Cold makes iron shrink.** |
| 4. (*a*) Fill a flask quite full of water; heat.<br>(*b*) Take apparatus shown in fig. 91. Heat with spirit-lamp, or, better still, place flask in a vessel containing hot water.<br>(*c*) Allow the apparatus to cool, or, better still, place flask in cold water. | The water runs over.<br>The water rises in the tube.<br>The water falls in the tube. | **Heat makes water swell.**<br>**Cold makes water shrink.** |
| 5. (*a*) Partly fill bladder with air, tie up opening; draw attention to the wrinkled surface of the bladder; place near fire.<br>(*b*) Remove bladder from fire.<br>(*c*) Place bladder close to fire. | There are no wrinkles in the bladder.<br>The wrinkles reappear.<br>The bladder bursts. | **Heat makes air swell.**<br>**Cold makes air shrink.**<br>**Heat makes air swell very much.** |

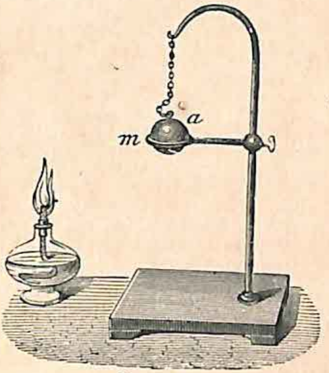

FIG. 90.

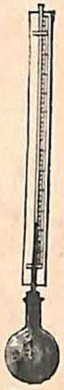

FIG. 91.

B.B. SKETCH.

$$\textbf{Heat makes}\left\{\begin{array}{l}\textbf{Iron,}\\ \textbf{Water,}\\ \textbf{Air,}\end{array}\right\}\textbf{swell.}$$

$$\textbf{Cold makes}\left\{\begin{array}{l}\textbf{Iron,}\\ \textbf{Water,}\\ \textbf{Air,}\end{array}\right\}\textbf{shrink.}$$

## COAL GAS.

**Things required.**—*Gas-jet in room, indiarubber tubing, matches, wide-mouthed jar, bottle, trough, water.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Turn on gas; apply lighted match. | Gas takes fire. | **Gas will burn.** |
| 2. Invert wide-mouthed jar over gas-jet, turn on gas, cork jar; uncork, let one or two children smell. | Nothing can be seen in jar, but there is a distinct smell. | **Gas can be smelt.** |
| 3. Turn on gas; ask child to put hand near jet. | A rush of gas can be felt against hand. | **Gas can be felt.** |
| 4. Partly fill trough with water, fill bottle with water, place hand over top of bottle, invert bottle, place hand and neck of bottle under water in trough, remove hand. The bottle, full of water, now stands inverted. Connect gas-jet and mouth of bottle by means of india-rubber tubing, turn on gas. | Gas rises through water in bubbles and drives water out of bottle. | **Gas takes up room.** |
| 5. Leave gas on for some time. | Gas can be smelt in many parts of the room. | **Gas spreads itself out.** |
| 6. (*a*) Take bottle from Experiment 4, *hold downwards*, apply light. | Gas *burns* quietly at mouth. | **Coal gas burns; coal gas mixed with air explodes.** |
| (*b*) Invert jar over gas-jet for a time, remove jar, *wrap in a cloth*,* apply a light. | An explosion takes place. | **It is foolish to go with a light into a room where there is an escape of gas.** |

*Notes.*—The Lesson can be completed by re-capitulating the Experiment showing the formation of coal gas from coal—6 (*a*), p. 9, Standard I. (A comparison can also be made between air, water vapour, and coal gas, as shown in B. B. Sketch.)

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* This precaution is taken to prevent dispersion of pieces of glass in case of fracture through explosion.

### B.B. SKETCH.

**Coal Gas**

Burns, smells, takes up room, spreads itself out; mixed with air explodes.

| | Coal Gas. | Water Vapour. | Air. |
|---|---|---|---|
| Burns ... ... ... ... ... | Yes. | No. | No. |
| Can be smelt ... ... ... | Yes. | No. | No. |
| ,, felt ... ... ... ... | Yes. | Yes. | Yes. |
| Takes up room ... ... .. | Yes. | Yes. | Yes. |
| Can be easily changed into a liquid | No. | Yes. | No. |

## AIR.

**Things required.**—*A large glass vessel containing water; tumbler; corked flask full of coal gas; scales, empty flask, spirit-lamp, bladder; syringe with well-fitting piston; candle, pickle jar, cork, and wire.*

**Introduction.**—*Recapitulate the main points in previous Lesson on Air (Standard I., p.* 18). *The Experiments may be again worked, or variations of those Experiments as detailed in pars.* 1 *and* 2 *below.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Invert a glass tumbler and press it into water contained in larger vessel (fig. 92). | The water rises only a little way in glass. | **Air takes up room.** |
| 2. (*a*) Weigh corked flask full of coal gas.<br>(*b*) Remove cork, let gas escape; weigh flask and cork again. | Second weight heavier than the first. | **Air has weight.** |
| 3. (*a*) Heat empty flask in flame of spirit-lamp; cork, weigh.<br>(*b*) Weigh same flask containing cold air. | Second weight heavier than first. | **Cold air is heavier than hot air.** |
| 4. (*a*) Take bladder partly filled with air; squeeze it.<br>(*b*) Close nozzle of syringe; press down piston (fig. 93). | The bladder is easily squeezed.<br>The piston can be pressed down. | **Air can be easily made to take up less room.** |
| 5. (*a*) Squeeze bladder filled with air; remove hand.<br>(*b*) Close nozzle of syringe; press down piston; remove pressure. | The bladder, on removal of hand, returns to its former shape.<br>The piston flies up. | **Air is elastic.** |

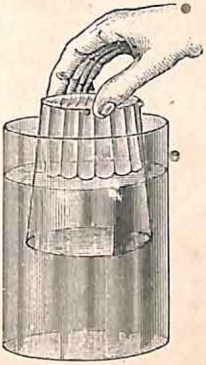


FIG. 92.—Experiment proving that air occupies space.

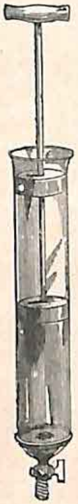


FIG. 93.—Apparatus for illustrating the compressibility and elasticity of air.

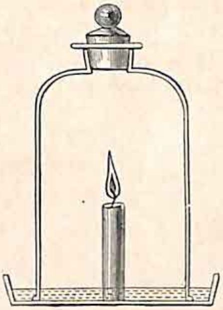


FIG. 94.—Experiment proving that air is necessary for combustion.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 6. (*a*) Lower lighted candle into pickle jar by means of wire passing through cork; cork jar. | The candle burns feebly and at last goes out. | **A candle, when burning, requires air.** |
| (*b*) Lower same lighted candle into same pickle jar but do not cork jar. | The candle continues to burn. | |
| 7. Stand lighted candle in dish of water; invert pickle jar over it. (A more elaborate form of this apparatus is shown in fig. 94.) | The candle goes out and the water rises a little way in the jar. | **A lighted candle uses up some air in burning.** |

## B.B. SKETCH.

**Air**
- **Takes up room.**
- **Has weight.**
- **Can be pressed.**
- **Is elastic.**
- **Helps candle to burn.**

## A FOUNTAIN.

**Things required.**—*Bottle containing water; cork, lamp-glass, piece of bladder, string, cardboard or metal disc; hollow indiarubber ball with several small holes and one larger one; watering can; water-level apparatus as in fig. 97; model fountain.*

**Introduction.**—*Recapitulate Lesson on Water (p. 16). To further impress the truths regarding pressure of water, the four following Experiments may be worked.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Take bottle containing water, insert cork, invert bottle, remove cork. | Water runs out. | **Water presses downwards.** |
| 2. Take tin canister with hole bored in side; cork hole, fill with water, remove cork. | Water runs out. | **Water presses sideways.** |
| 3. (*a*) Cover one end of lamp-glass with piece of tightly stretched bladder, force covered end into water. | Bladder bulges upwards. | **Water presses upwards.** |
| (*b*) Take lamp-glass in one hand, with other hand hold string which runs through glass and is attached to cardboard (or metal) disc which is pulled by string tightly against glass. Let string go. Again arrange apparatus, but this time let child place hand under disc; once more loosen string. | Disc falls unless the hand pushes upwards to support it. | |
| (*c*) Arrange apparatus a third time, and now lower into water; let string go | Disc does not fall (fig. 95). | |

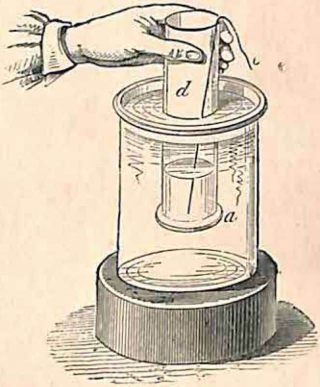


FIG. 95

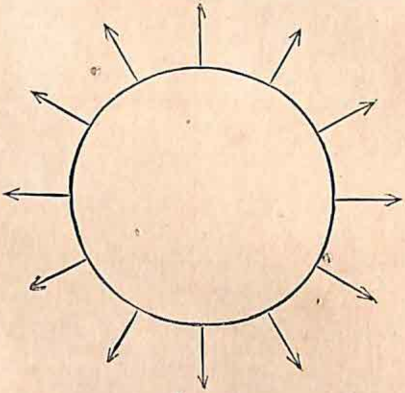


FIG. 96.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 4. Fill hollow indiarubber ball with water by pouring water into the largest hole; cover hole with thumb; squeeze ball. | Water squirts out through all the open holes (fig. 96). | **Water presses in all directions.** |
| 5. (*a*) Pour water into can; note height of water in spout.<br>(*b*) Pour water into one of tubes of water-level apparatus (fig. 97). | Water is as high in spout as in can.<br>Water forces its way up other tubes till it is on same level in each. | **Water tries to find its own level.** |

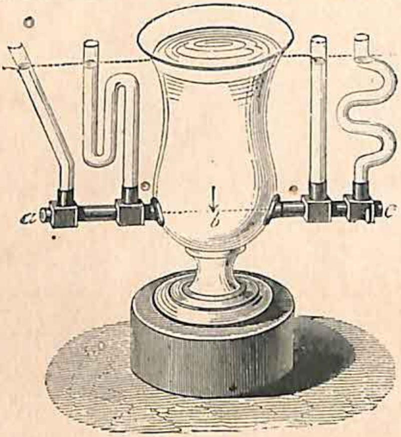


FIG. 97.

6. Construct a model fountain as follows: take a large can with hole at or near bottom. Place can on top of cupboard. Attach one end of indiarubber tubing to hole in can; the other should terminate in some kind of nozzle. Pour water into can; note different results obtained on different elevations of can and show that the higher the can, the higher the fountain. By this time the children will have easily noticed that the jet of water does not rise so high as the can. Account for this as follows: place piece of sponge in nozzle, notice serious diminution in height of fountain. Get children to reason that some of the force is lost by the water in forcing its way through the sponge, and that in the same way the water loses some force in pushing through the indiarubber pipe.

### B.B. SKETCH.

**Water.**
**Presses downwards,**
**,, sideways,** **in all directions.**
**,, upwards,**
**Tries to find its own level.**

A Conversation and Information Lesson could well follow here upon the nearest fountain, or the nearest waterworks reservoir; see figs. 98 and 99 below.

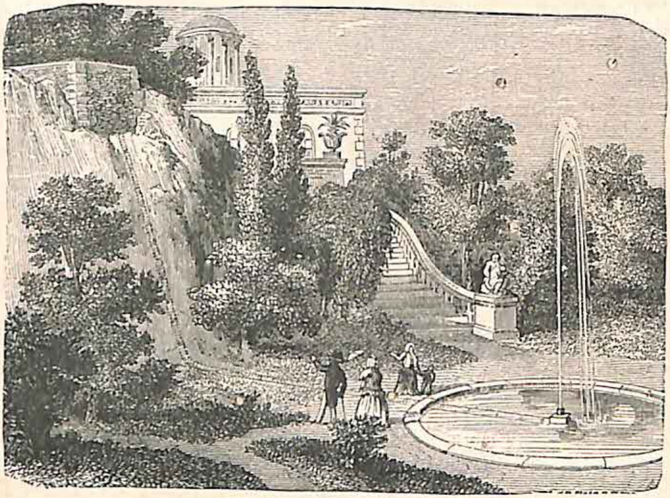


FIG. 98.

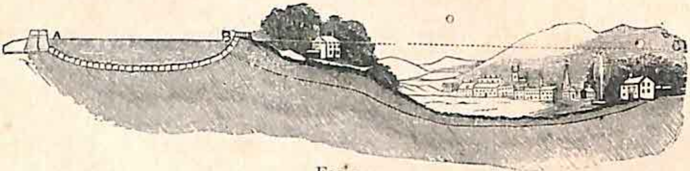


FIG. 99.

## PARTS OF A FLOWER.

**Things required.**—*A sufficient number of buttercups to supply each member of the class with one or more specimens. Slates and pencils, or paper and blacklead pencils. The scholars to bring their own specimens of flowers.* (*This will send them to the fields and supply the Outdoor Work for this Lesson.*)

### CALYX or CUP.*

Hold up a specimen flower in front of the class and call attention to the calyx. Let them observe that this is the outer covering of the flower. Tell them the word *calyx* means a cup. Under the guidance of the teacher the children will then note:—

---

* This is an Observation Lesson, and the primary aim of the teacher should be to teach the children to observe. The nomenclature used is of secondary importance.

1. That there are five yellowish-green little leaves
2. That each little leaf is distinct.
3. That all the little leaves are alike; *i.e.* they are regular.

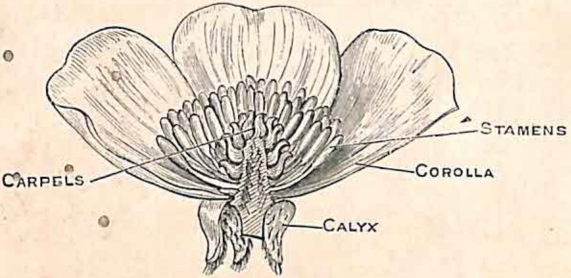


FIG. 100.—Vertical section of flower of buttercup, showing the different parts.

This is best done by directing the children to *carefully pluck off the sepals*, and to lay them side by side on their slates or paper. The teacher will next recapitulate these facts, writing them on the B.B. The class will then copy them on to their slates, thus:—

**Cup** or **Calyx** = five parts; each distinct, regular, and greenish.

Under this statement the children will then *draw the outline of a sepal from the object itself*, the teacher assisting on the B.B. if necessary.

## COROLLA or CROWN.

The teacher will proceed in the same way with the next covering—the corolla. The class will note:—

1. There are five leaves, each called a petal (= leaf).
2. These leaves are larger than the sepals.
3. They are yellow in colour.
4. Like the sepals, they are distinct.
5. Also like the sepals, they are regular.
6. At the base of each petal is a tiny scale containing the *nectar* which attracts insects.

Recapitulation, B.B. writing, slate writing, and drawing will follow as before, thus:—

**Crown** or **Corolla** = five petals; each distinct, regular, and yellow.

## STAMENS.

Call attention to the stamens, which should be plucked off carefully. Class to note:—

1. They are numerous.
2. That each one has a threadlike stalk.
3. Each stalk has a yellow head.
4. From the yellow heads comes a yellow dust.

Then proceed as in the previous cases. The B.B. will show:—

**Stamens** = numerous; each has a stalk, head, and pollen.

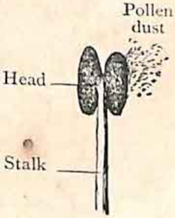


FIG. 101.—Stamen of buttercup.

### PISTIL

The part of the flower now left is called the pistil. As before, under the guidance of the teacher, class to note :—

1. A number of little green bodies, each called a carpel, which means *fruit. When ripened the carpels form the fruit.*
2. The *carpels* are distinct.
3. Each *carpel* has a tiny head (stigma).
4. Also a short stalk.
5. A larger portion at the bottom—a seed case. In the ovary is a small body which becomes the seed case.

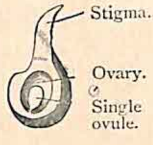


FIG. 102.—Carpel of buttercup.

Proceeding as before we get :—

**Pistil** = many carpels ; each carpel has a stigma, short stalk, and seed case.

## PEA BLOSSOM.

**Things required.**—*Plenty of specimens of the pea flower ; a picture or diagram of a butterfly with its wings raised ; a razor or a very sharp knife ; some pea pods in various stages of growth.*

OUTDOOR WORK.—Visit a garden where the meadow pea, the sweet pea, or the garden pea is growing and in blossom. The Lesson can be given in the spring with the very early peas, or in the summer with the summer peas, or in the autumn with autumnal peas. Call attention to the tendrils. The pea has a weak stem, and wants some assistance to stand upright. *The tendrils give this assistance by clinging with their little hooked ends to anything they touch.* Having completed the examination, sufficient specimens should be plucked for the Classroom Work.

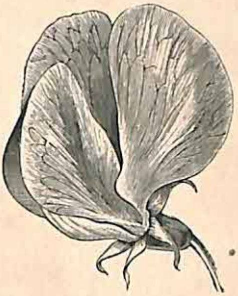


FIG. 103.—Sweet pea.

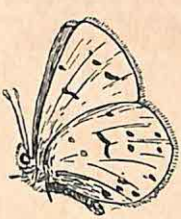


FIG. 104.—The Azure or Holly Blue. Under side.

CLASSROOM WORK.—First call attention to the general shape of the blossom. It is butterfly shaped. Show a picture of a butterfly with its wings raised, and point out the general resemblance.

| Observations and Experimenst | Illustrations and Inferences |
|---|---|
| **CALYX.** | |
| 1. It is green and all in one piece. | Apparently only one sepal. |
| 2. Note the five little teeth. | There are five sepals. |
| 3. The five sepals have grown together. | **To keep out the wet and to keep away unwelcome insects from the flower-bud.** |
| **COROLLA** | |
| 1. The petals differ in size—such flowers are called irregular (fig. 105). | All irregular flowers are fertilised by insects. (Tell this.) The irregularity compels the insects to visit the nectary in one particular manner. |

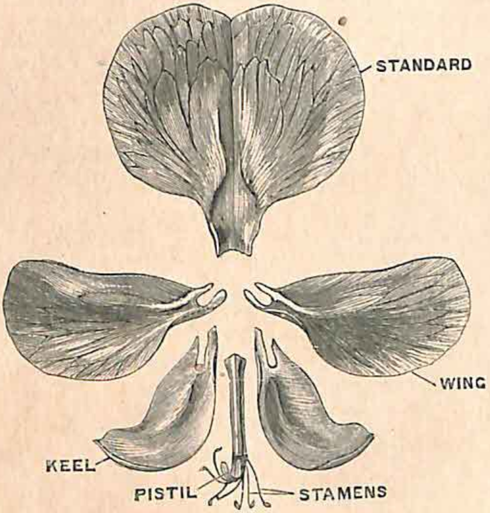


Fig. 105.

| | |
|---|---|
| 2. The *largest* petal stands up at the back of the flower like a flag or **standard.** | |
| 3. Below this are two petals, one on either side, and alike, which are called the **wings.** | |

| OBSERVATIONS AND EXPERIMENTS | ILLUSTRATIONS AND INFERENCES |
|---|---|
| 4. Below these come two other petals, which are joined together so as to make them boat-shaped. These are called the **keel.** | |
| 5. There are lines on the petals, all leading to one place on each petal—the **nectary.** | |
| EXPERIMENT.—Take the two ends of the wings of the *sweet pea* between the finger and the thumb, and press them down so as to imitate the effect produced by the pressure of an insect. The keel and wings are depressed, while the pistil and the stamens are partly uncovered. As soon as the fingers are removed the flower goes back to its natural position. All the children should do this Experiment under the guidance of the teacher.<br>(*It will be necessary to tell the children that the visits of insects to flowers are very necessary for the flowers, and that the flowers want the insects to come in contact with the stamens and the pistils. This will be sufficient here, but the matter will be dealt with fully in a later Lesson.*) | See figs. 106 and 107. |

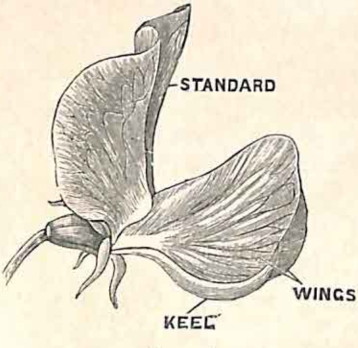


FIG. 106

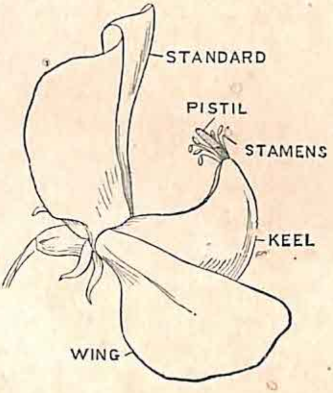


FIG. 107.

## STAMENS.

| | |
|---|---|
| Cut a section through the middle of the flower from below upwards, and note ten stamens. | |

| OBSERVATIONS AND EXPERIMENTS | ILLUSTRATIONS AND INFERENCES |
|---|---|
| **PISTIL.** | |
| 1. Open the tube carefully—the pistil is shut up inside it. | |
| 2. Show various specimens illustrating the development from the flower to the pea-pod.<br>(*If the Lesson be given in summer or autumn the blossoms of that season can be used, and the pea-pods of the previous season.*) | The carpel grows larger, and forms the pod with the row of peas. |

Drawing and composition to follow as usual.

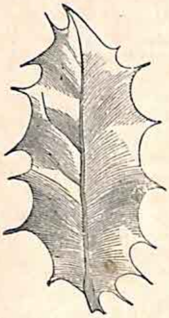
## EVERGREEN PLANTS: THE HOLLY.

**Things required.**—*Specimens of flowers, leaves, and wood of holly; at a later period some berries (or some preserved berries).*

OUTDOOR WORK.—Visit the tree, and note :—

1. Its handsome cone-shaped appearance.
2. Its stiff-looking growth, and the abundance of its little branches and leaves.
3. The deep green, shining leaves with spines. Top leaves probably no spines.
4. Its white flowers (in May) clustering round the branches in the same position as the berries afterwards take up.
5. A seasonable visit at a later period will show its many red berries. (Some varieties have yellow or even white berries.)

CLASSROOM WORK.

| OBSERVATIONS AND EXPERIMENTS | RESULTS AND INFERENCES |
|---|---|
| **FLOWERS.** | |
| Distribute flowers for examination, and note their general appearance with a view to future recognition. | |
| **FRUIT.** |  |
| Examine the berries. (Distribute one to each member of the class.) They are somewhat round, fleshy, and contain four seeds. | |
| **LEAVES.** | |
| Distribute leaves to each member of the class, and note :—<br>1. They are green, leathery, and shining. | FIG. 108.—Spiny leaf of the holly. |

| Observations and Experiments | Results and Inferences |
|---|---|
| 2. They have spines. Why? | **The holly leaves grow spines to prevent certain animals eating them.** |
| 3. Smell the leaves. | **They have no smell.** |
| 4. Taste them; they have a milky, bitter taste. | **The bitter taste is to prevent animals eating them.** |
| 5. Feel them; they are smooth and shiny. Why? | **To get rid of the snow, the weight of which might damage the trees.** |
| 6. Tear the leaves; they are tough and leathery. Why? Remember that they are evergreen, and live several years. | **To protect them from animals who would eat them, and to give them strength to endure their greater age.** |

## WOOD.

| | |
|---|---|
| Various specimens will be required.<br>Examine piece of wood of holly, and note :— | |
| 1. It is as white as ivory.<br>2. Feel it; it is very hard.<br>3. Show a piece of polished wood. It takes a fine polish.<br>4. Show a piece of ebony wood. Feel it; it is very hard. It is dearer than holly wood. | Hence used for *veneering* and *inlaying*; is used sometimes instead of ebony for handles of teapots. In these cases the holly wood is stained black. |

Drawing and composition to follow.

## EVERGREEN PLANTS: THE IVY.

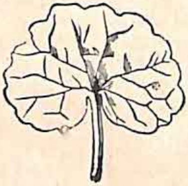
**Things required.**—*Specimens of flowers, leaves, and wood; several young shoots of ivy, planted months before the Lesson; some preserved berries.*

OUTDOOR WORK.—Visit ivy growing, and note :—

1. It is a climbing plant.
2. The *stem* is tough-looking, woody, and round.
3. Its *leaves* are dark green: **they are evergreens.**
4. Compare the *stem* with the bulk of the plant; it is small.
5. Little roots grow from any part of the stem. Note that they push into the crevices, shape themselves to it, and then grow hard and woody. Examine a young rootlet and an older specimen to show this.
6. Generally the plant is in a more or less shaded position—clinging to some wall or tree.
7. The *leaves* hang vertically, with their broad sides turned towards the light. Contrast with the leaves at the top of the plant. These spread out and grow one above the other. **They do not hang vertically, because the light falls directly on them.** Note that these leaves also differ in shape—they are pear-shaped.
8. In October or November note the flowers. They are on the top branches. They are a pale, greenish yellow, and are very nice-smelling.
9. The dark-coloured berries follow the flowers in thick and numerous clusters, remain on the plant throughout the winter, and do not ripen till the next spring.

CLASSROOM WORK.

| OBSERVATIONS AND EXPERIMENTS | RESULTS AND INFERENCES |
|---|---|
| **FLOWERS.** | |
| Distribute flowers for examination, and note :—<br>1. Their general appearance with a view to future recognition. | |
| 2. The *pistil* has five carpels. Each carpel has its own *style*, but the styles are all joined into one. | **The berry will have five seeds.** (Examine a berry, and show this.) |
| **LEAVES.** | |
| Distribute leaves, and note :—<br>1. They are undivided or lobed. | |
| 2. There are no stipules ; *i.e.* the leaves are imperfect. | |
| 3. The leaves vary very much. Some are pear-shaped, whilst the leaves of the flowering branches are oval or lance-shaped. | |
| 4. Cut off a young shoot of ivy (*climbing*), and plant one end in moist earth several months before the Lesson. Then show the shoot to the class. | The claspers have pushed into the soil and become like roots which have never seen the light. |
| 5. Handle the leaves ; they are smooth, shiny, and have a thick skin. Remember they are evergreen. | **They are smooth and shiny to get rid of the snow. The thick skin probably protects them from cold.** |
| 6. The ribs of the leaf are large and strong. Why? | **The leaf is heavy, and wants a strong support.** |
| 7. The number of lobes is odd (three, five, or seven). Each side of the leaf slopes towards the central vein, which runs on to the odd and end lobe, which hangs downwards. | **This is to drain the water off the leaf.** |
| 8. Cut off a slip from a flowering branch of the *tree ivy*. Plant it some months before the Lesson. Then show it to the class. | It will grow into a bush with pear-shaped leaves and *no tendrils.* |
| 9. Cut off a slip from a *climbing ivy*, and plant it with sticks for climbing. This also should be done a long time before the Lesson. | It will produce a climbing plant ; *i.e. have tendrils.* |

| OBSERVATIONS AND EXPERIMENTS | RESULTS AND INFERENCES |
|---|---|
| **STEM.** | |
| Show a piece of ivy stem, and compare it with the bulk of the plant. [Outdoor Work (4).] The stem is small and weak. | **Hence it climbs for support.**<br><br>FIG. 109.—Kidney-shaped leaf of the ground ivy. |

Drawing and composition to follow.

## HEDGEROW TREES: THE ELM.

**Things required.**—*Specimens of flowers, elm nut, leaves, and the various specimens of wood as detailed in the Lesson; specimens of bark, both outer and inner.*

OUTDOOR WORK.—The tree should be visited in March or April, when it is in blossom. Later visits should also be paid, so as to notice the effect of the foliage in summer and autumn. Meantime, class to note:—

1. It grows in woods and hedges, but is often planted elsewhere.
2. The flowers grow before the leaves.
3. The flowers grow in clusters and are of a bright pink colour.
4. It is a handsome tree: tall, with stout trunk and spreading branches.
5. It has a rugged bark with large bosses.
6. Many suckers are sent up by the roots.
7. On a later visit call attention to the dark green leaves.

CLASSROOM WORK.

### FLOWERS.

Distribute flowers to the children, and let them notice their colour and general appearance so that they could again recognise them.

### FRUIT.

Examine a specimen of the elm nut; it is a one-seeded little nut, winged all round. Compare it with the winged seed of the blossom, and so show the origin of the fruit.

## LEAVES.

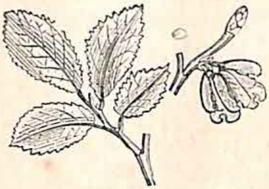


FIG. 110.—The common elm.

Distribute leaves for examination, and note :—

1. Their saw-like or tooth-like *edges*.
2. They are not equal at the *base*.
3. Their *colour*—dark green (bright yellow in autumn).
4. Their *size*—from two to three inches (larger in Scotch elm).
5. They have *stipules*; the leaf is therefore perfect.
6. Their *arrangement*—the leaves are alternate and simple.

## WOOD.

1. Show a piece of decayed elm wood, and note the tracks of the *bark-boring beetle*. It shows a regular system of tunnels. Explain their formation.
2. Show specimens of elm wood from the school museum, and look at its grain ; it is very close.
3. Take a piece of elm and pieces of some other ordinary woods (deal, &c.). Take a chisel and mallet, and split each piece before the class. **The elm wood is very strong and tough, and less liable to split than almost any other wood.**
4. Show a bit of elm wood which has been kept in water for months. Apparently it is unaffected by the water. **Water does not make it rot.**
5. From 2, 3, and 4 show that it is suitably used for the keels of ships and boats, the naves and spokes of wheels, for foundation piles and wet planking.
6. Show a specimen of wood with a *boss*. Large bosses are much prized for cabinet work and turnery.
7. Show a piece of its *bark*. It is used in dyeing and sugar refining.
8. Show specimen of *inner bark*. Let children feel it ; it is milky. Taste it ; it is bitter, and an astringent. (Explain.) Used as a medicine for skin diseases.

Drawing and composition to follow.

# HEDGEROW TREES: THE ASH.

**Things required.**—*Specimens of flowers, wood, leaves, fruit ('Locks and Keys') ; a feather, some bark, an ash stick.*

OUTDOOR WORK.—The tree should be visited in March or April, and the Lesson should be given about that time. Later visits will be required, as for the elm, to note the effect of the foliage in summer and autumn.

1. The children are to note that it grows in woods and hedges, but is often planted elsewhere. It is often found by brook or river side.
2. Note its *light grey*, *nearly smooth*, bark.
3. Note its black buds.
4. Note its *flowers*, with their purple-black stamens. The flowers are small, dense, and branched.
5. At a later visit, when the tree is in leaf, note its great beauty as shown in
   - (*a*) Its elegant form.
   - (*b*) The feathery lightness of its branches.
   - (*c*) The graceful waving of its branches.
6. At a later visit collect some of its *fruit*, and examine it. The fruit is the well-known 'Locks and Keys' of the village children.
7. Note the poor condition of the grass or crops under its shadow. **Its dense foliage shuts out the light and warmth of the sun. Hence the poor condition of the grass or crops beneath its shade.**

CLASSROOM WORK.

## FLOWERS.

Distribute flowers for examination, and let the children note their general appearance so as to aid future identification.

## FRUIT.

Show some 'Locks and Keys.' The fruit is winged, is about an inch and a half in size, and hangs down in large drooping bunches. Hence we see that the fruit of the ash and the elm (and the maple) belong to the same class of winged fruits.

## LEAVES.

Distribute specimens for examination if the season be suitable; if not, work with dried specimens. Note :—

1. The leaves are notched, sharp-pointed, and cut into a number of leaflets. Compare them with rose leaves.
2. Note the *arrangement* of the leaflets; on either side of the central stalk, like the barbs of a feather. Show a feather in illustration of this, and compare the two.
3. Note the *number* and *size* of the leaflets; they are from one to three inches in size, and there are from four to seven pairs in one compound leaf.
4. Young leaves sometimes given to cattle when grass is scarce.

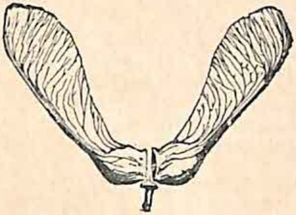


FIG. 111.—Winged fruit of the maple.

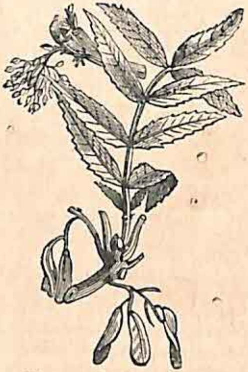


FIG. 112.—The ash.

## WOOD.

Show specimens, and let class examine them.

1. It is strong and lasting—next to the oak for these qualities.
2. It is the sweetest forest wood for *fuel*.
3. A useful powder is made from its rotten parts.
4. Show specimen of bark. It is used for dyeing and tanning calves' skins.
5. The wood is valued by wheelwrights, cartwrights, coachmakers, joiners, and turners, because of its elastic nature. Show an ash stick to demonstrate this.

Drawing and composition to follow.

# VEGETATION AND CULTIVATION

## (First Lesson).

**Things required.**—*Two shallow boxes or trays, the one filled with dry mould and the other with clayey soil; knife, chisel; a young plant with rootlets; some small weeds; small stones or seeds; some powdered chalk.*

Outdoor Work.—The class should be taken to see the different processes of cultivation practised in the neighbourhood, and these observations should extend to both field and garden work.

Classroom Work.—The Classroom Work should embrace a recapitulation of the observations made during the Outdoor Work *plus* the following simple Experiments :—

| Observations and Experiments | Inferences |
|---|---|
| **PLOUGHING.** | |
| 1. Take a shallow box or tray filled with clay, and another filled with dry mould. 'Plough' up the mould with a knife. Then plough up the clay, and contrast the thick lumps of clay with the finely divided and dry mould. Then show the rootlets of some young plants, and ask into which soil the tender rootlets would force their way with the greater ease; which soil also would get the greater amount of air. | **The roots would grow farther and easier into dry soil, and so would get more food from it.**<br>**The dry soil also gets more air, and is therefore more fertile.** |
| 2. Place some small weeds (bits of tender plants will do) in a mass of stiff soil. Then plough one part thoroughly with a knife, and 'dig' another part with the chisel. The weeds are uprooted and cut up. | **Ploughing helps to destroy weeds.** |
| 3. Take a mass of stiff soil, and bury some small objects (stones, beads, seeds, &c.) in it. Suppose these to represent the larvæ, grubs, &c., of insects. In the stiff condition of the soil the grubs are safe, and can feed on and destroy the roots of the crops. Now 'dig' or 'plough' up as before. The grubs are turned up, exposed, and destroyed, either by birds (rooks, daws, &c.), who eat them, or by the frost, which kills them. | **Ploughing frees the land from grubs, which eat the roots and so damage the crops.** |
| 4. Show a piece of iron. Rub it with the fingers; nothing comes off. Treat similarly a piece of rusty iron; something (the rust) can be rubbed off. What made the iron change? | **Cultivation by turning up the soil, and by exposing it to the air, causes it to be powdered like the rusty iron.** |

| Observations and Experiments | Inferences |
|---|---|
| **DIGGING.** | |
| 1. Take a mass of compact mould, and 'dig' it with a chisel, imitating spade-work. Note the process; each spadeful is broken up and mixed with other earth. Then press the mould firmly together again, and imitate the action of ploughing; the soil is turned up, but is neither so much broken up nor mixed with other earth. | **Spade-work is better than ploughing, and gives better cultivation.** |
| 2. Press the mould into a compact mass again, and place little heaps of powdered chalk upon it to represent manure. Now show that with the spade (chisel) the manure can be evenly distributed over the ground. Then take another mass of compact mould (or the same mass worked up again), place chalk as before, and imitate the action of ploughing; the manure is not so evenly distributed as with the spade. | **Spade-work is better than ploughing for manuring the land.** |

Composition to follow.

## VEGETATION AND CULTIVATION

(Second Lesson).

**Things required.**—*Clay and mould in shallow boxes or trays as before; two Bunsen burners or two spirit-lamps; some powdered chalk; knife, chisel, comb or toy rake, bit of pencil, leaf, small cylinder.*

Outdoor Work.—As in previous Lesson.

Classroom Work.

| Observations and Experiments | Inferences |
|---|---|
| **DRAINING.** | |
| 1. Burn some clay over a Bunsen burner or spirit-lamp. Then crumble it up, and contrast it with another and unburned piece. It is *lighter, drier, warmer, and more exposed to the air.* | **Draining makes the land more fertile.** |
| 2. Take some saturated clay soil and some light soil. Sprinkle them with powdered chalk or anything similar to represent manure. Pour water on both from the spout of a watering-can. The chalk is washed *into* the dry soil, and partly *off* the clay soil, some of it thus being wasted. The chalk sinks more easily (to the roots, if they were present) in the dry soil than in the clay. | **Drained lands are best for manure.** |
| 3. Heat equally and gently some saturated clay and some light soil over two Bunsen burners or two spirit-lamps. Let the children suppose these lamps or burners to represent the sun. Then let the children feel the two soils; the light soil is the warmer. | **The heat of the sun is largely wasted in drying up the water on undrained lands.** |

| Observations and Experiments | Inferences |
|---|---|
| 4. Take a mass of saturated clay and some dry soil. 'Dig' both with a chisel or knife. Let the class observe which is the easier. (A child might be called out of the class to perform this experiment.) The dry soil is easier dug than the clay. | **Drained land is easier to work.** |

## HARROWING OR RAKING.

| | |
|---|---|
| 1. Take a mass of stiff soil, and 'plough' it into clods with a knife. Then draw a toy rake or wide-toothed comb over the small lumps or clods; the clods are broken up, more or less, so that a larger surface of the soil is exposed to the air. | **Harrowing gives the soil and roots more air.** |
| 2. Take some dry mould, and make some holes in it with a knitting-needle or a piece of pencil. Drop some small seeds into the holes. Then draw the comb along the soil; the holes are covered up. | **Raking the soil covers up any seeds which may be exposed.** |
| 3. Tear up a leaf into bits (bits of paper will do as well), and spread these over a mass of loose mould. Let the bits (leaves or paper) represent weeds. Then draw the comb along the surface of the mould; the weeds are gathered up. | **The rake or harrow is useful for collecting weeds which have been ploughed up.** |

## ROLLING.

Refer to the practice of rolling lawns, roads, garden paths, cricket-pitches and fields. Then take a mass of loose earth, and roll it with any small and sufficiently heavy cylinder. Class to note that—

1. It smooths the surface.
2. It presses the soil together.
3. Loose soil becomes firmly pressed round the roots.

Composition to follow.

## BUDS (A Spring Lesson).

**Things required.**—*Specimens of the buds mentioned in the Lesson will be required; specimens of stocks, grafts, and buds, to illustrate grafting and budding.*

Outdoor Work.—A visit should be paid to the neighbouring trees and other plants in bud. Class to note :—

1. The position of the buds :
   - (*a*) At the end of a stem or branch : **end buds.**
   - (*b*) In the axil of a leaf : **axil buds.**
   - (*c*) On other parts of the stem : **chance buds.**

2. Their structure :
   - (*a*) A central mass, more or less the shape of a sugar-loaf.
   - (*b*) Little green leaves.
   - (*c*) In most winter buds there are outside some scales as a protection against cold.
   - (*d*) Sometimes hairs (*willow*).

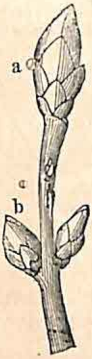


FIG. 113.—*a*, end bud ; *b*, axil bud, the leaf in the axil of which it was produced having been removed.

CLASSROOM WORK.—This, with the aid of suitable specimens, should embrace a recapitulation of the Outdoor Work.

1. The position of the buds can be again illustrated.

2. Their structure can be entered into with more detail. Invite the class to bring their own specimens.

3. Show a *piece of grape vine with tendrils.* The tendrils proceed from chance buds, and so illustrate the third class of buds.

4. Show a young stem with buds, and point out (fig. 113) :—
   - (*a*) That buds begin to grow by the growth of the internodes, which separate the leaves from one another and form the branch.
   - (*b*) The end buds increase the stem in length.
   - (*c*) The side buds produce the branches.

5. Demonstrate the method of budding.
   - (*a*) Show a superior variety and an inferior one of the same family. The superior variety should be in bud.
   - (*b*) Remove a bud from the superior variety, together with the surrounding bark.
   - (*c*) Make a T-shaped incision in the inferior variety.
   - (*d*) Insert the bark of the bud carefully beneath this cut.
   - (*e*) Bind up the cut to protect it from the air.
   - (*f*) Note that the bud grows in the same way as the graft.

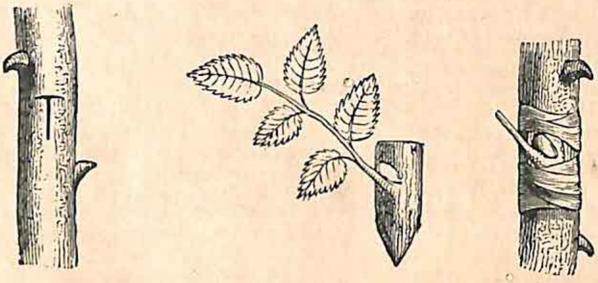


FIG. 114.—The various elements in the process of budding.

6. Explain pollarding. If you injure the *end* bud you stop the growth of the stem in length. As a result the *side* buds often acquire greater powers of growth.

Drawing and composition to follow as usual.

## THE FOOD OF PLANTS.

**Required.**—*As in the last Lesson, the teacher should read through the Lesson some time previous to giving it, so as to make the necessary preparations and to commence the necessary Experiments in due time.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Grow a few *beans* and a little *maize* in distilled water; other specimens in *moist sand*. | Only three or four leaves and a few side rootlets grow. All growth has stopped. | **The plants require something more than water and sand** |
| (*b*) Examine the *seeds* of the grown specimens, and compare them with some fresh ones. | *The food material has disappeared.* | **Growth has taken place at the expense of the store of food in the seed.** |
| 2. Take a few *leaves and twigs from a growing plant*, and weigh them. Dry them for a few minutes and weigh again. (*Show the leaves, &c., in their natural state. Then place them in a sand-bath about six or eight inches above a low Bunsen flame.*) | *They weigh much less*, about three-fourths of the weight having disappeared. | **Something has gone, and from the dried look of the leaves we believe this to be moisture.** |
| 3. (*a*) Place the *dried leaves* of the previous Experiment in a porcelain crucible, and heat over a Bunsen burner. | The leaf *chars*. | **This shows the presence of carbon.**<br>[Compare with a piece of charcoal.] |
| (*b*) Raise the temperature till redhot, and maintain this high temperature for four or five minutes. | A little *grey ash* is left. | **All the carbon has burnt away** |
| 4. (*a*) Take a *glass of muddy river water*, and let it stand. | The minute solid particles gradually sink to the bottom of the glass and form a fine deposit of mud. | **The water, then, contains matter which cannot be filtered off, and which, therefore, must pass into the roots with the water.** |
| (*b*) Decant a little of the clear liquid, and filter. Then pour the filtered water into an evaporating-dish, and boil off the water. | We get something left at the bottom of the dish. | **We might think that this matter is the same as the grey ash, but in another Lesson we shall see whether it is or not.** |

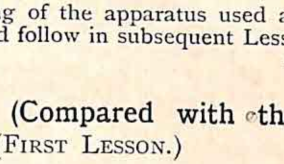
### B.B. SUMMARY.

1. **Plants want something more than Water or Sand.**
2. **The greater part of a leaf is composed of Water.**
3. **Plants contain Carbon, and therefore want it as food.**
4. **They also contain a Grey Ash, which they want as a food.**
5. **Some substances, as food, pass into the roots with the water.**

Where possible, drawing of the apparatus used and composition on the food of plants should follow in subsequent Lessons.

## THE MOUSE (Compared with the Rat and Water-Rat.) (FIRST LESSON.)

**Things required.**—*A mouse in a cage ; pictures of rat and water-rat ; specimen teeth and feet of the three animals.*

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **TEETH.** | | |
| *Examine the teeth, and note :—*<br>1. The mouse has four front, sharp, broad, chisel-shaped teeth. The back teeth are flat, hard, and blunt. Note also that there are no tearing teeth, and the lower front ones are narrow and sharp. The angle of the lower jaw is roundish. | Compare the mouth of the mouse with that of the rabbit.<br><br> <br>FIG. 115.—The cutting tooth of a gnawing animal. *e*, enamel ; *d*, dentine. | **The chisel-shaped teeth are suited to gnawing, as in the rabbit.**<br>**The mouse has no tearing teeth, and therefore does not eat flesh.**<br>**The grinders are adapted to a mixed diet.** |
| 2. The common rat has very strong teeth. The lower gnawing teeth are narrow, pointed, and smooth. Note the two front grinders and four back grinders in each jaw. | The teeth of all three grow as fast as they wear out. When all the teeth are present the top and bottom ones check each other's growth, but if one be missing the other will keep on growing till it may kill the animal by preventing it from getting any food.<br>Contrast with our own teeth. | **Its strong teeth enable it to gnaw its way through almost anything—even wood and lead.**<br>**The loss of a tooth is a very serious matter to a mouse or a rat.** |
| 3. Note that the enamel of the grinders in the water-rat is folded, so as to produce the appearance of *a double triangle on a crown.* The front teeth are yellowish. | | |

## PAWS AND CLAWS.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| *Examine and note:—*<br>1. The legs of the mouse are four in number, short, and armed with sharp claws. | <br>FIG. 116.—A mouse's foot. | **Its short legs help it to get through small holes.**<br>**Its sharp claws enable it to climb up anything with a rough surface.** |
| 2. Note that the feet of the common rat are jointed so loosely to its hind limbs that they can be turned half round. Note that the front feet have four toes and a small thumb, but the hind feet have five toes. Note also that the claws are very sharp, and that the *hind claws* are so made that they also can be turned round. | <br>FIG. 117.—A rat's claws.<br>From the dead specimens the feet of the mouse and common rat could easily be compared with those of the water-rat, to show the presence and absence of hairs on the feet. | **The arrangement of the hind feet and claws of the common rat enables it to run head first down anything with a rough surface (tree or wall).** |
| 3. Look at the soles of the feet of the water-rat; they are hairless. | | **The absence of hairs makes swimming easier.** |

## TAIL.

| | | |
|---|---|---|
| 1. Note that the tail of the mouse is long, and covered with short hairs. | The harvest mouse twines its tail round corn-stalks, and slides from its nest down to the ground. | **The tail may be a climbing aid.**<br>**The water-rat steers with its tail.** |
| 2. The tail of the rat is not relatively so long. | | |
| 3. In the water-rat the tail is about one-third its whole length. | | |

## WHISKERS.

| | | |
|---|---|---|
| Note that the whiskers are long and numerous, and are placed on either side of the large, pointed, and keen-scented nose. | Compare with the cat, and thus elicit their use. Remind class that these are night animals. | **The whiskers are feeling and measuring organs.** |

## THE MOUSE (Compared with the Rat and Water-Rat). (SECOND LESSON.)

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **EYES.** | | |
| Note that they are large, bright, and wide open. | Compare with the cat again. | **The mouse and rat are night animals, and can see in the dark.** |
| **EARS.** | | |
| 1. Note that they are large and well developed.<br>2. The ears of the water-rat are remarkably short and roundish. | All animals with large ears are very quick of hearing. | **They have many enemies; hence good sight and hearing very necessary.** |
| **COVERING.** | | |
| 1. Note that the mouse is clothed with a soft, warm fur, which is of a dull colour, being generally a dusky brown or a greyish tint.<br>The common rat is called the brown rat. Call attention to the colour of the water-rat. | Compare with the cat again.<br>It will be noted that the colours are similar to those which prevail in the natural surroundings of these animals. These are more or less cases of 'protective mimicry.' (*Explain.*) | **Night animals require warm coats for their night work.**<br>**The dull colour is for safety — a bright colour would easily be seen.** |
| 2. Note that the body of the mouse and of the rat in each case is the right shape for squeezing through small holes. | | |

### COMPARATIVE SUMMARY.

The B.B. notes should be condensed from this summary.

| | MOUSE | RAT | WATER-RAT |
|---|---|---|---|
| **Teeth.** | Strong and chisel-shaped; back teeth flat. | Very strong and chisel-shaped; back teeth flat. | Strong and chisel-shaped; back teeth with folded enamel. |
| **Tail.** | Long. | Not so long. | Shorter. |
| **Feet.** | More firmly jointed. | Loosely jointed. | More firmly jointed; hairless soles. |
| **Claws.** | Hind claws *cannot* be turned back. | Hind claws *can* be turned back. | Hind claws *cannot* be turned back. |
| **Ears.** | Large, broad, and well developed. | Large. | Very short and roundish. |
| **Covering.** | Fur. | Fur. | Fur. |
| **Eyes.** | Large and bright. | Large. | Smaller. |

Drawing and composition to follow.

## A FISH (First Lesson).

### HOW FITTED TO LIVE IN THE WATER.

**Things required.**—*Backbone of a herring; a large glass vessel filled with water and containing live fish; air bladder of a herring or other fish; a small elastic bladder; a dead herring* (*fresh*) *and a knife; a shark's tooth; a spindle* (*a bit of wood shaped like a spindle will do*); *fresh egg; salt water.*

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| **WEIGHT.** | | |
| 1. Show the *backbone* of a herring. Note the tiny bones which are so troublesome when eating a herring; they are very light. | To be able to live in the water *a fish must be of such a weight as to float easily and continuously, to rise and sink deeper at pleasure, to be able to move swiftly and easily, to breathe under water, to stand the cold, and to find its food.* | **For these purposes it will require to be made differently to a man, a bird, or a reptile.** |
| 2. Take a fresh egg, place it in salt water. If it sinks, add salt; if it floats, add water until the egg floats anywhere in the water. Compare with fish. | Bulk for bulk most fish weigh the same as the water, like the egg. | **Hence fish can swim in the water.** |
| 3. Carefully open a *herring* and show the *air bladder.* Call attention to the fish swimming in the glass vessel. They rise and fall. | Sometimes the bladder is small, sometimes larger; when it is smaller the air in it is pressed closer together and weighs heavier. When the bladder returns to its natural size again the air becomes lighter. | **All fish which have an air bladder can alter their weight.** |
| 4. Get a small elastic bladder and blow it out partly, tie the neck. Note that it does not easily rise in the air. Place it before a fire; the bladder becomes larger and rises more easily. | The fish can make its bladder larger or smaller by the aid of some muscles. | **When the bladder is made larger the fish rises in the water; when the bladder is made smaller the fish sinks in the water.** |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| **SHAPE.** | | |
| 1. Point to the *shape* of the fish; most fish are spindle-shaped. Show a spindle. | Some are *flat*, and these live at the bottom; some are *long* (eel), and these creep through crevices; some are *roundish* and sluggish, and may float about. | **The spindle-shaped body of the fish is the best shape for motion in water.** |
| 2. Take the large vessel filled with water and move a piece of spindle-shaped wood (a 'tip-cat') through it. Then move various irregular or bulky pieces through; there is more wash, and therefore more resistance. | The teacher could further illustrate by a comparison of the *side stroke* and *breast stroke* in swimming, by the *shape of boats* (tapering at both ends), and by the shape of *torpedoes*. | |
| 3. Point to the fish again and note that there is no neck. The head and body form one whole. | | **The joining at once of the head and body gives strength, and helps the fish to dart through the water.** |

## A FISH (Second Lesson).

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| **COVERING.** | | |
| 1. Note the covering of the fish—scales. Note their beautiful colour. | The scales grow from both the outer and the inner skin. All scales are something like teeth in their formation. The scales correspond to the hair of animals and to the feathers of birds. Wool, hair, or fur would impede the progress of the fish. | **The scales offer little or no resistance to quick motion through the water.** |
| 2. Note that the scales are flat and lie in sacs of the under skin. Note that they overlap each other like roof tiles from head to tail, and *as the fish swims they are pressed close to the body.* | | |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. Let the children run their hands along the fish *from head to tail*; it is smooth and somewhat slimy. Refer to the practice of polishing the bottoms of racing boats and of cleaning the bottoms of ships so as to keep them smooth. | The skin of the fish contains some little cells, which burst and cover the fish with a slimy substance. | **The slimy skin makes it still easier to go through the water.** |
| 4. Take a dead herring (fresh) and scrape it with a knife from *head to tail*; few scales are scraped off. Now scrape it from *tail to head*, as a fishmonger does; many scales are removed. | When scraped from tail to head the knife gets under the scales and removes them, but the scales lie too close to be scraped off the other way. | **The scales are fastened to the body so as to make swimming easier.** |

## TEMPERATURE.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 1. Let the children handle a *live* fish; it is cold. Let them feel each others hands; they are warm. | Many fish can stand a colder temperature than that of the water generally, and fresh-water fish more so than sea fish. | **It has cold blood, and so can stand cold water.** |
| 2. Carp, roach, chub, minnows, eels, &c., go to sleep in the winter. But generally the temperature of the fish is about the same as that of the water. | Any angler will be able to tell the boys that they do not fish for these in the winter. | **Great cold causes some fish to go to sleep in the winter.** |

## MOVEMENTS.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 1. Call attention to the action of the tail in the swimming fish, and note that the tail fin strikes the water like a man strikes it with his scull when sculling with a single oar. | The tail is really a fin, and is called the tail fin. It will be seen that the fins correspond to our arms and legs. | **The tail is the chief organ of movement, and it must be supplied with strong muscles to do its work.** |
| 2. Take a dead fish and point out the tail, belly, back, and paired fins. | | |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 3. If we cut off the fins, the fish rolls over on its side. | [*Tell this experiment rather than do it.*] | **The other fins are used for balancing.**<br>**The paired fins also help to raise and lower the fish in the water, and to some extent act as rudders.** |

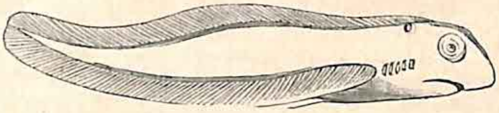


FIG. 118.

| | | |
|---|---|---|
| 4. Put a dead fish into the water; it floats upside down. | Children have probably seen dead fish so floating in the water. | **The solid muscular back is heavier than the parts below, but the fins keep the body right side up during life.** |
| 5. Show the backbone of a fish, and let the class note that it easily bends within certain limits. | A herring bone generally answers well. | **Hence the graceful and easy bending of the body in the swimming live fish.** |

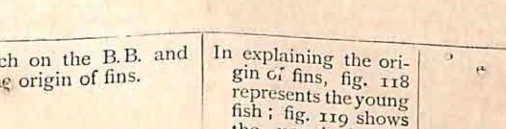


FIG. 119.

| | | |
|---|---|---|
| 6. Put a sketch on the B.B. and explain the origin of fins. | In explaining the origin of fins, fig. 118 represents the young fish; fig. 119 shows the unpaired fins, and the breast and belly paired fins. | |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 7. Cut off the fins from the dead fish and show the rays. | The fins are really folds of skin spread out and containing a large number of rays or bony spikes. These keep the fins extended and give them strength. | |

## A FISH (THIRD LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **FOOD.** | | |
| 1. Throw little particles of food, each of a different kind, into the large glass vessel containing the live fish, and note :<br>(*a*) The fish eat almost anything.<br>(*b*) They swallow their food whole. | Fish feed on worms, shell fish, insects, other fish, mud (for its living creatures) ; sea and fresh water weeds, &c. ; but most of the food is animal food. | **Fish are not dainty.** |
| 2. Tell the class that most fish feed on one another ; they are cannibals. They breed enormously fast. | *Sprats* swallow the spawn and eggs of *herrings*, the *whiting* feeds on *herrings*, the *cod* on *whiting*, the *shark* on the *cod*, and so on. | **If fish did not breed very fast they would soon die out.** |
| 3. Open the mouth of the dead fish (herring or mackerel, &c.) and show its teeth. They are numerous and sharp. There are no cutters or grinders. | Teeth are sometimes found all over the mouth, top, bottom, and even on the sides. Teeth are sometimes sharpened like a saw ; show a shark's tooth in illustration. | **Fish want good teeth because they live on flesh.**<br>**The teeth are formed for seizing and holding.** |
| 4. Examine any number of fish, and all will be found well supplied with teeth. | The teeth do a great deal of work. | **New teeth grow to take the places of those worn out.** |
| 5. We cannot see so well under water as when out of the water. Note the *eyes* of the fish ; they are large. | The food may lie hidden where the fish cannot see it, and so it has a very delicate sense of smell to scent its food. Again, the fish may have to rake about for its food like the sturgeon, and to do this it is blessed with a keen sense of touch. | **The eyes of the fish are large to enable it to see under water.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 6. Sometimes our eyes water, the water coming from the tear glands; this is an arrangement to keep our eyes moist. | | **The fish has no tear glands because the water keeps its eyes moist.** |
| 7. When we are under water we generally *close* our eyes. Call attention to the fish in the glass vessel; their eyes are open. | | **The fish wants its eyes open to hunt for its food; hence it has no real eyelids.** |
| 8. Take a dead fish and show its lips; they are horny. Compare or contrast them with ours. Tell class that fish often have *bony plates on the tongue*, and they have already noted that *they swallow their food whole.* | Remind class of the varied nature of the food, and that it is always soaked with water.<br>Again, in taking a pill we swallow it whole. *Why? Because we do not wish to taste it.* | **The fish has little sense of taste.** |
| 9. It may sometimes happen that fish cannot get any food at all. | Food may be scarce even in the water. | **Many fish can go without food for a long time, and fresh-water fish more than sea fish.** |

## BREATHING.

| | | |
|---|---|---|
| 1. Take up a dead fish and show its gills. Note that they are fringelike organs, and reddish in colour. Put a lens over the reddish portions; numerous blood-vessels will be seen through the skin. Note how thin the skin is. | Blood is sent through the gills to be acted on by air. | **The gills of the fish are like our lungs; they take in air to purify the blood** |
| 2. If you put a fish into water which has had all the air driven out of it (say by boiling), it would soon die. | There is always air in water unless it has been specially driven out. | **The fish, like us, cannot live without air.** |
| 3. Keep a fish out of water and it dies. Why? | Examine the gills of a dead fish; they shrink. | **The shrunken gills cannot do their work. Water is necessary for the proper action of the gills.** |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 4. Let the class note the action of the gills of the live fish in the large glass vessel; the fish seem to be constantly drinking. | The water, which contains air, passes out by the gills, where the blood has nothing between it and the air but a very thin skin. | **What appears to be constant drinking is the constant breathing of the fish.** |

Drawing and composition to follow.

## PLAICE (Compared with the Herring).

**Things required.**—*Pictures of herrings and plaice; fresh specimens of both; small pair of scissors; saucer of water; magnifying glass. If possible a visit should be paid to an aquarium to see the swimming action of both fish, and to otherwise study their habits.*

| Plaice | Herring |
|---|---|
| **SHAPE.** | |
| *Show the specimen plaice* and ask its shape—flat. Point to the picture. Ask for other flat fishes—soles, dabs, flounders, turbot, brill. | *Show specimen herring*; it is spindle-shaped. Ask for some names of similarly shaped fish; most fish are shaped like this. |
| **EYES.** | |
| Both on one side of the head. *How is this?* The young fish is very tiny, shaped like the herring, and floats about on top of the water. It soon begins to get compressed, *i.e.* to grow thin and deep. It then sinks down to the bottom and rolls over on to one side. The eye on the under side would become damaged by the sand and mud, so the young plaice tries to protect it. In such a case we should shut that eye, but the plaice has no eyelid; hence nature helps it gradually to twist its eye round to the top side. The eyes show danger only; the plaice does not seek food by sight. This twisting of the eye brings the nostrils to the top side, and the mouth also, which is all on one side.<br>The plaice spawns at sea, and its eggs float about and are scattered. | In the herring the eyes are seen to occupy their usual position. The herring sinks deep down where there are swarms of small creatures on which it feeds; hence it seeks its food by sight. It only comes to the surface on dark nights, and once a year (July and August) for spawning. It is then that the herring fisheries are carried on. Herrings are also said to have some sort of voice (they squeak), and to have organs for hearing.<br>The herring spawns in dense masses near the coast. |

## GILLS.

| PLAICE | HERRING |
|---|---|
| These are found at the back of the mouth. We already know that the gills are the breathing organs. *To show these the teacher should take up a specimen plaice or sole, &c., and with a pair of scissors cut from the mouth to the slit behind the head so as to lay them bare.* They are seen to be like bony hoops, lying one behind the other. The water enters the mouth and passes out through the gills—between the hoops and so out by the slit. *Now from the under side cut open the bony hoop again and show the class that there are four on each side, all separated from each other by the slits through which the water flows.* Next *cut off a piece of one of the hoops and put it in a saucer containing some water.* Let the class see it closely, and some very delicate threads will be seen attached to the hoop. These are filled with blood. The process of aeration will now be understood from the Lesson on the Fish. Next *put the piece of hoop under a magnifying glass*; the hoop is seen to be jointed. Why? **The joints make them bend easily so as to move easily and let the stream of water through.** | *A specimen herring should be taken and the gills laid bare and inspected by the class.*<br>It is assumed that the children will already understand the action of the gills in the herring from the Lesson on the Fish.<br>The two should then be compared and contrasted. |

## MOVEMENTS.

| PLAICE | HERRING |
|---|---|
| They move along the bottom of the sea, or bury themselves in the sand or mud. Some exude a slimy substance which causes the sand (which they first disturb) to stick to their top side, and so make them almost indistinguishable (sole). Even in aquariums it is sometimes difficult to detect where these fish are lying. Furthermore, the under side is white, but the top side is the same colour as the sea bottom. **This is done for protection from their enemies.**<br>The body is fringed with fins, which are not so much use as in many other fishes. There are only three (one back fin, one anal, and one tail fin). The fins are soft, and jointed in their rays. *This should be shown to the class from the specimens.* Note that *there are no breast or belly fins.*<br>They are side swimmers and very graceful in their movements. They have no air bladder, for they live at the bottom, are slow swimmers, and trust to hiding rather than to flight. When they rise in the water they do so with a strange wavy motion of the whole body. When they wish to rest they sink gradually downwards with an easy gliding motion. The scales are very beautiful, and we already know how they assist in swimming. We also notice a number of small red spots. | Like the plaice, the herring is soft finned, and *this also should be practically demonstrated by the examination of one of the specimens.* Their bodies gleam with a bright light in the water; hence the herring will trust to speed and flight for protection. This cannot be seen from the specimens, because a herring dies as soon as it is removed from the water, and it then loses this gleaming. It has an air bladder, which in the adult is connected with the food canal by means of a tube. *Put sketch on B.B.* in illustration.<br>*Examine the fins of both fish.* The back fin is not so long as in the plaice; but it has breast and belly fins. The use of the fins is already known. The herring swims upright in the water. |

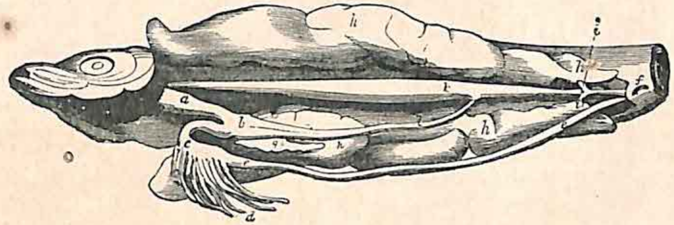


FIG. 120.—Inside of herring. *a*, gullet; *b*, *c*, stomach, with its appendages, *d*; *e*, intestine; *l*, duct of the swimming-bladder, *k*; *h*, roe.

COMPARATIVE SUMMARY.

The B.B. notes should be condensed from this Summary.

| | PLAICE | HERRING |
|---|---|---|
| **Shape.** | Flat; spindle-shaped when very young. | Spindle-shaped. |
| **Eyes.** | Both on one side of the head. | On opposite sides. |
| **Nostrils.** | ,, ,, ,, | ,, ,, |
| **Mouth.** | On the top side. | On both sides. |
| **Movements.** | Slow, graceful; side swimmer. | Swift; upright swimmer. |
| **Air bladder.** | None. | Has air bladder. |
| **Fins.** | Three only (back, anal, tail). | Back, anal, tail, breast, and belly fins. |
| **Colour.** | White one side and dark the other. | More uniformly coloured. |
| **Protection.** | By hiding. | By flight. |
| **Food.** | Sought by touch. | By sight. |

Drawing and composition as usual.

## THE MOLE (FIRST LESSON).

**Things required.**—*A live mole; a spade; large picture of mole; skeleton of a mole or a diagram or picture of the skeleton; the body of a mole just dead; a tip-cat and a small block of wood; microscope; a vessel containing water.*

OUTDOOR WORK.—Take the class into the fields where molehills exist. Note that they are small heaps of loose earth. Select one and dig carefully to show its structure. In looking for the mole's home the best places are under large stones, roots of trees, or thick bushes; never near paths or roads.

CLASSROOM WORK.

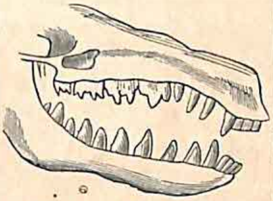
| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **SHAPE.** | | |
| 1. Point to the body of the mole. It is long and roundish with pointed snout, short tail, and short limbs; muscles of the neck very strong. | Long legs and a long tail would be in the way for burrowing. | **The whole body is formed for tunnelling with the least exertion and with the greatest speed.** |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 2. Point to the skeleton, and note the enormous shoulder blades rising far above the spine. Show a small block of wood and a tip-cat. Which could be pushed into the ground the more easily? | The shoulder blades and muscles are for strength. | **The mole must be strong to force its way through the earth.** |

## SNOUT.

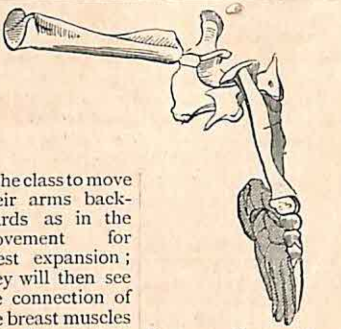
| | | |
|---|---|---|
| 1. Note its pointed shape and compare with the end of the tip-cat. The nose is very long. | There is an extra bone which runs into the snout and makes it strong and easily bent. | **The long nose gives it a powerful sense of smell to guide it to its food.** |
| 2. Take the head of the mole which has just died, and bend back its snout. The snout springs back again into its proper position. | [It is said that a captive mole buried several inches in the ground will at once scent a piece of meat placed on the surface.] | **The easy bending of the nose enables it to dig with safety.** |

## TEETH.

| | | |
|---|---|---|
| Open the mouth of the dead mole and show its teeth. Note :—<br>(*a*) They have jagged points.<br>(*b*) All *types* of teeth are present.<br>(*c*) There are no broad flat grinders. | <br>FIG. 121.—Teeth of mole. | **The teeth are formed for holding and tearing, and not for chewing.** |

## PAWS AND CLAWS.

| | | |
|---|---|---|
| From the body of the mole show :—<br>1. The *fore-legs* are bowed and very powerful. | The mole digs forwards. | **The mole wants its chief strength in front.** |
| 2. The *hind-legs* are not nearly so powerful. | The hind-limbs are used to throw the earth behind it as it burrows. | |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. Point to the chest, and tell the class that there are great breast muscles. | Ask the class to move their arms backwards as in the movement for chest expansion; they will then see the connection of the breast muscles with the motions of the arms. | <br>FIG. 122.—Bones of fore-limb of mole. The bones are short and thick, showing great strength. |
| 4. Hence all the animal's *chief power lies in its fore-quarters.* | | |
| 5. Show the fore-paws. They are very strong, bare, wrinkled, and generally dirty. They are turned backwards and upwards, and the palms are wide and flattened. Turn the hand over and illustrate. | Refer to the hands of a clerk and a mechanic, and compare them. | **The condition of the hand depends on the nature of the work it does. The position of the fore-paws is favourable for shovelling.** |
| 6. Turn to the skeleton of the mole, and in the fore-paws point out an extra bone. | This is shaped something like a sickle, and grows out from the wrist bone. | **This bone gives greater spread and power to the fore-paws.** |
| 7. Take the body of the dead mole and show the claws. They are large, strong, sharp, and curved. There are five on each foot. | Compare the claws with our nails. | **The claws are formed for scraping and digging.** |

## THE MOLE (SECOND LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| EYES. | | |
| 1. Show the live mole, and note :—<br>(*a*) The eyes are very small.<br>(*b*) They are black, beady-looking objects.<br>(*c*) They are quite hidden in fur.<br>The eyes can be seen equally well by putting the dead mole in water. | '*Blind as a mole.*' They probably cannot see very much. *We now see the necessity for their strong sense of smell.* | **Large eyes would get filled with dirt and become sore; so would uncovered eyes.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **EARS.** | | |
| Examine the mole and look for its ears; none can be found. The ground helps it. Refer to the practice of putting ear to the ground to hear distant sounds of galloping, &c. | No outside ears, but good inner ones. | **Owing to its poor eyesight good hearing is very necessary to warn it of its foes.** |
| **FUR.** | | |
| 1. Let the children feel the fur, and note :— | | |
| (*a*) It is velvet-like. | The varying thickness in each hair gives it its velvety aspect. | **Its velvet coat prevents the dirt from clinging to its body.** |
| (*b*) Put the dead mole into water. The water becomes dirty. | | **The coat is only relatively clean.** |
| (*c*) It is close. | | **This makes the coat warm, and protects it against the damp, chill ground.** |
| 2. Let the fur be stroked. It will be noted that the tips of the hair do not point in any particular direction, but may be pressed in any direction. Let the children smell the skin; it is unpleasant. | | **This aids it in its tunnelling.** |

## FOOD.

An insect-eater; greedily devours earthworms and grubs. It has a big appetite; hence must move about quickly to get enough food. It is destroyed by farmers because it is supposed to injure the crops by its burrowing. It is also said to sink wells to collect water when not easily found otherwise. It digs deep into the ground after worms and so helps to drain the soil, and it also brings up the soil to the surface for the growing crops. The grubs it feeds on would damage the crops very much; hence these facts show that really it is the farmers' friend.

## HOME.

The burrows are in very straight lines. The central apartment is nearly round, and the roof is almost level with the ground above; this will have been noticed in the outdoor work. Around this chamber are two galleries, one of which is just level with the ceiling, whilst the other is at some height above. The upper circle is much smaller than the lower. Now, note that five short descending passages join the galleries with each other, but that the only entrance into the chamber is from the upper gallery, out of which three passages lead into the ceiling chamber. It will thus be seen that the mole when it enters the fortress from one of the tunnels has first to get into the lower gallery, from there to go to the upper gallery, and so descend into the chamber. There is another entrance into the chamber from below. A passage dips downwards from the centre of the chamber, and then, taking a curve upwards, opens into one of the larger tunnels. There are seven or eight of these branching in different directions, and they never open into the gallery opposite one of the entrances into the upper gallery. The mole is therefore obliged to turn to the right or left as soon as it enters its home before it

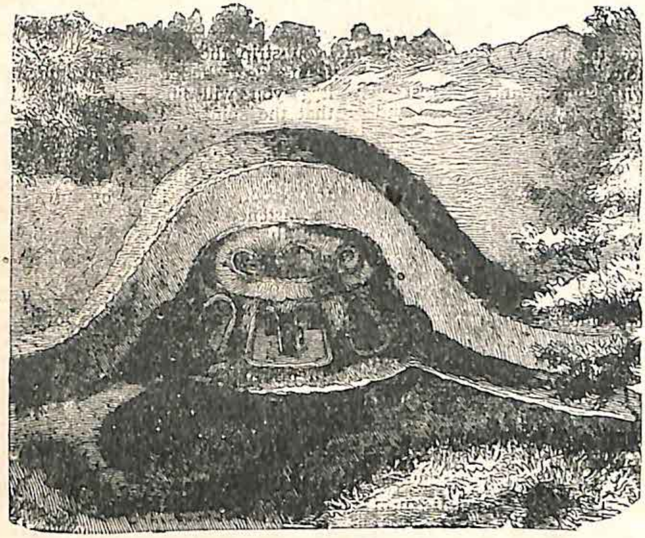


FIG. 123. - The fortress and galleries of the mole.

can find a passage to the upper gallery. The true nests, which are made of dried grass or blades of corn, are placed along the tunnels, and often at some distance from the fortress. The fortress is for safety, but the nests are generally placed at the junction of two or more passages, so that in case of alarm the mother and young may escape. (Grant Allen says much of this is due to the too lively imagination of a French naturalist.)

---

Drawing and composition to follow.

## THE HEDGEHOG.

**Things required.**—*A tame hedgehog; a good picture of the hedgehog.*

OUTDOOR WORK.—An attempt should be made to see the hedgehog in its natural surroundings. It should be sought in the hollows of rocks, or of trees, in thickets, or in a hedge bank. Failing these it will even build itself a burrow. Search for its nest. This will be found to be made of grass, moss, leaves, or hay, and covered in above to keep out the rain. It lies rolled up in a ball in its home during the day, and probably two will be found together, as they live in pairs.

Classroom Work.—*The children should be invited to bring a tame specimen for the lesson.* It takes readily to domestic life and soon becomes tame, allowing itself to be handled without rolling itself up in a ball. The reason for its name should be pointed out.

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| **COVERING.** | | |
| 1. Show the tame hedgehog, and note that its back is covered with spines, and the rest of the body with hairs and bristles. | If you strip the skin from a dead hedgehog you will find that the spines are finely grooved along the sides, and have a head like a pin's for a root, which is so fastened to the skin that the spines stick out in all directions. | **The hedgehog is neither big enough, strong enough, nor relatively fast enough to fight or run; hence its defence by spines.** |
| 2. The spines are about one inch long, and are of a whitish tint, with a bar of black through their middle. The hair on the under part of the body is a yellowish white. | The spines take some time to grow; for the first few weeks after birth the young hedgehog has only soft quills, and looks almost like a young bird. | **Its colour helps to protect it, as it is not readily seen.** |
| 3. *Feel* the spines; they are firm and elastic. | | **The spines are very elastic, and so make a nice soft cushion to fall on.** |
| 4. Get the animal to roll itself up, and let children feel it. It is a ball of prickly spines. | Few dogs can safely tackle a hedgehog. The dog in its efforts to unroll the animal gets wounded about the mouth, nose, and paws. | |
| 5. Make an inclined plane of the blackboard and table, and push the hedgehog down it. It rolls itself up and falls down, without hurting itself. | | |
| **MOVEMENTS.** | | |
| 1. It rolls itself into a ball by the action of a powerful muscle arising from the head and neck on either side, and forming a loop round the end of the body. | Trace the course of this muscle, either on the specimen or on the picture. | **This powerful muscle enables it to roll itself up quickly.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. (*a*) Note the big body and short limbs. The legs are short and somewhat feeble.<br>(*b*) There are five toes on each foot which are armed with claws. | The body is about ten or twelve inches long and about six inches high. | **The build of the animal is not suitable for speed; hence the necessity for other means of defence.** |
| (*c*) The tail is about one inch long. | The tail is required neither for climbing nor balancing; hence a short one will do. | **A long tail would be in the way when rolling itself up into a ball.** |

## HEAD.

| | | |
|---|---|---|
| Note from the live specimen :—<br>1. The sharp, pointed snout. | | **The sharp snout enables it to grub and root for its food.** |

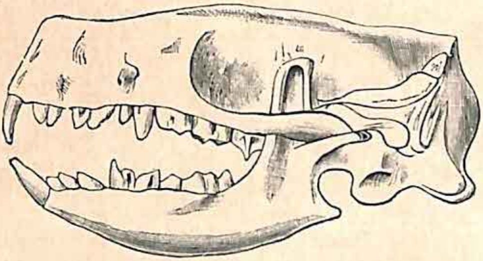


FIG. 124.—Head of hedgehog.

| | | |
|---|---|---|
| 2. The loose flap on each side of the nostrils. | | **The loose flap acts as a protection to the nostrils.** |
| 3. The small black eyes. | | **The eyes are suited to night hunting.** |
| 4. The distinct, short, naked, rounded, dusky ears, which are less than half the length of the head. | | **Such an animal requires good hearing.** |

## TEETH.

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| Put a sketch on the B.B. (fig. 124), and note :— | | |
| 1. *Three* cutters on either side in each jaw ; the central pair being long and prominent. | This should be shown from a sketch, as it will scarcely be possible to illustrate from the live specimen. The skull of a hedgehog would be best for this purpose. | **The teeth are suited for cutting and crushing.** |
| 2. *Seven* upper grinders on each side, and *five* below, with rounded knobs. | | |

## FOOD.

It is an insect-eater. In addition it eats mice, young birds, frogs, fallen fruits, roots, and other vegetable matter ; fond of flesh, and will even kill and eat a snake. The poison of the adder takes no effect on it. It bites the snake two or three times across the back to prevent it running away, and then eats it, commencing with the tail. Has an enormous appetite, and is useful in kitchens and gardens to hunt down cockroaches ('blackbeetles'). In the winter it wraps itself up in its warm nest and sleeps till the spring. The gipsies say it first stores up birds, mice, and crab apples.

Composition to follow.

# THE COMMON GRASS SNAKE (First Lesson).

**Things required.**—*A tame pet snake (failing this, a specimen snake in a box of methylated spirits) ; skeleton of snake ; two separate but adjacent vertebræ, or a ball and socket joint ; a large sheet of smooth glass. In the skeleton, if the head bones are required, they will have to be fixed, as they are loose in the live animal and are only kept in their places by the skin.*

The following observations on the snake might be useful :—Efforts should be made to find a specimen of this timid and very harmless creature. It is easily tamed, and becomes a pet. It should be looked for in hedgerows, and its peculiar rustle can often be heard as we walk along a country lane. It can also be found in damp meadows, woods, and by the side of ponds, where its favourite food, the frog, lives. It sleeps all through the cold weather, so that a winter hunt should be directed to the discovery of the holes in which it buries itself. A number sleep together, intertwining themselves before going to sleep. Several hundreds have sometimes been found in one hole. They are not easily discovered, and sometimes they turn up in unexpected places like cottage gardens. If a sleeping specimen should be discovered warmth will soon revive it. But failing the discovery of a snake itself, its eggs may sometimes be discovered on dunghills close to stables and cattle sheds, or in a heap of decomposing vegetable matter, or on a sun-favoured patch of land, the choice being made for *warmth* in every case. The eggs will be easily recognised, as they are white, oval bodies, about the size of a blackbird's egg. They are from fifteen to twenty in number, are laid at separate times, but all within a short space of each other. When new-laid they are covered with a moist sticky substance, which causes the eggs to stick to each other. This soon dries, and the eggs are then firmly joined. The mother's duty seems to end here, for she leaves the eggs to take care of themselves. If eggs should be discovered, an attempt might be made to hatch them.

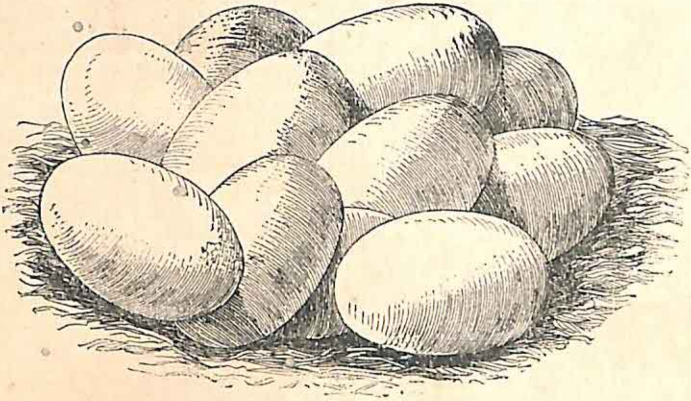


FIG. 125.—Eggs of the common snake

CLASSROOM WORK.—The observations are to be made from the specimen itself.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **SHAPE.** | | |
| 1. Note the long, narrow, and roundish body. | The first two points will be explained under the head of 'Movements.' | |
| 2. Note that it has neither legs, fins, claws, wings, nor hands. | | |
| 3. Show the skeleton; it is practically all backbone and ribs. | | The backbone is very strong and flexible. |
| 4. Note the large number of bones (vertebræ) in the backbone. Show two separate ones, and show that they fit each other like a ball-and-socket joint (fig. 126). | If the separate vertebræ of 4 cannot be obtained, illustrate with a ball-and-socket joint and a B.B sketch. | |
| 5. Note that the same arrangement occurs with the ribs, so that all the bones are worked in ball-and-socket joints. | | The ribs can be moved backwards and forwards at will. |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 6. Note that the under ends of the ribs are free—*i.e.* they are not fastened to anything. | | **The 'free' ribs allow the body to be very much stretched, and help it to move its scales.** |
| 7. Note that each vertebra bears two ribs. | | |

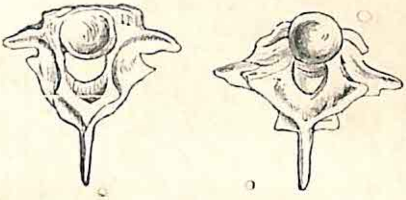
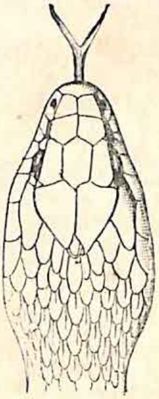


FIG 126.

## COVERING.

| | | |
|---|---|---|
| 1. The body is covered with scales. | Compare the scales with hair, fur, feathers, &c. | **The loose scales are used to help the snake to move about.** |
| 2. Note that these are fixed in front, but are loose behind. Their points turn backwards. |  FIG. 127.—Head of the common snake, showing scales. | |
| 3. The scales on the lower part of the body are larger, and are generally made into bands. | | |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 4. The whole body is covered over with a very thin skin. | The thin skin is 'shed' at intervals. For some time before the 'shedding' begins the creature is dull and uneasy, but when it has completed its new coat it is much brighter in colour and much more active. | **The thin skin is a protection for the scales.** |
| 5. Note the colour; a sort of brown, with a greenish tint, or an olive-tinted grey. The under parts are lead-colour. | | **The marks and colours help to distinguish it from the viper.** |
| 6. Note the bright yellow patch on either side of the neck. | | |
| 7. Note a double chain of small dark spots which run along the back. | | |
| 8. Along each side can be seen a single row of somewhat larger spots. | | |
| 9. Handle the snake with gloves, unless it is a tame pet, when it may not be necessary. | The snake, when handled, can sweat out from its body a substance with a very nasty smell, which clings to the hand for hours, and is very difficult to remove, even by repeated washings. | **The unpleasant smell which the snake gives out is used as a means of defence.** |

## THE COMMON GRASS SNAKE (SECOND LESSON).

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| TEETH. | | |
| Show the skeleton of the snake, and note :— | | |
| 1. A number of very small, sharp teeth. | The teeth are not set in sockets like ours. | **The teeth are formed for holding, hence when any prey is seized it cannot escape without breaking off all the snake's teeth, which is highly improbable.** |
| 2. The teeth are all made solid into the jaw. | | |
| 3. They all point backwards. | | |
| 4. The absence of cutters and grinders. | There is no biting and no chewing in taking its food. | |

## MOVEMENTS.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| *Tell* the following :— | | |
| 1. It climbs trees. | In climbing a tree it keeps its body as straight as possible, presses it against the bark, and glides swiftly up the tree.<br>Its general movement is explained as follows :— *With the help of its ribs it pushes its scales forward, and then draws them backward. The result is that the loose edges of the scales 'hitch' against the ground or tree.* | **The scales are used as limbs.** |
| 2. Glides as fast as most horses run. | | |
| 3. Leaps great distances. | | |
| 4. Shoots from branch to branch on a tree like a monkey. | | |
| 5. Is a capital swimmer. It is very fond of taking a bath in hot weather. The coiled-up body is below the surface of the water, the head just above (for breathing). In this position it will watch for newts. | | **Like the fish also, its scales help it to swim.** |
| 6. Place the pet snake on a large sheet of very smooth glass. The snake will move with difficulty. | If the surface is smooth enough the snake cannot move at all. | **On smooth surfaces there is nothing for the scales to 'hitch' to.** |

## HOW IT SWALLOWS ITS PREY.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 1. Recall that the snake has neither cutting, tearing, nor grinding teeth. | | |
| 2. Its food in many cases consists of animals twice as broad as itself. | Its chief food consists of frogs, mice, eggs, and young birds. | **Its food must be swallowed whole.** |
| 3. When the snake eats a frog the process of swallowing *is done by movements of the jaw, which is pushed forwards and backwards. At each forward movement it takes a fresh hold of its prey with the points of its teeth, and then, when the jaw is drawn back, it pulls the prey farther into its mouth.* | Compare the 'hitching' of the food with the 'hitching' of the body—the one is done with the teeth, and the other with scales.<br>When the snake eats anything with fur or feathers it generally swallows it head first. | **The food is hitched down the throat by the aid of the teeth.**<br>**Otherwise the fur and feathers would hinder the swallowing.**<br>[Demonstrate this by stroking the wrong way a piece of fur or feathered skin.] |

The following points concerning the process of swallowing may be of interest :—

(*a*) When the frog begins to pass into the snake's mouth the bones of the snake's head begin to separate—they are not fastened together, like ours.

(*b*) The skin is stretched also ; the scales are quite separate in the neck.

(*c*) The two sides of the lower jaw separate, and yet are still capable of the backward and forward movement.

(*d*) The skin becomes more stretched, and looks like goldbeater's skin. The shape of the bones and the colour of the victim can be seen through it.

(*e*) As the frog passes on, the skin and bones resume their natural position.

Drawing and composition to follow.

## THE COMMON VIPER (ADDER).

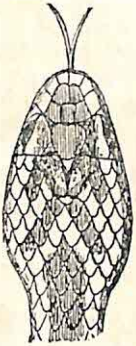
**Things required.**—*A specimen of the viper preserved in methylated spirits; a specimen of the common grass snake similarly preserved : a lens.*

The following observations might be useful :—In this Lesson the Outdoor Work had better be confined to a visit to a museum where a live adder may be seen.

*There is no risk in meeting a viper, for it will always retreat before you.* Some assert that it is a timid creature, and only dangerous when trodden on or attacked. If such a remote chance as a bite should occur, suck the wound and rub in well with ammonia. It will be found chiefly in dry, warm places, such as heaths, sandy commons, thickets, and low brushwood. It is also fond of basking in the sun, where it lies coiled up.

CLASSROOM WORK.—All observations to be made from the specimen.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **COVERING.** | | |
| 1. Note the colour—dark olive-brown, yellow, red, grey, or nearly black. | It varies very much in colour. The yellow specimens are the largest. Contrast carefully with colour of snake. | |
| 2. Note the two black stripes on top of the head, and forming a letter V (fig. 128). | This V-shaped mark distinguishes it from all other English snakes. | **It gets its name from the V-shaped mark on its head.** |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 3. Note that, like the common grass snake, it is covered with scales, above which is a very thin skin. | <br>Fig. 128.—Head of the viper. | **The scales and skin serve the same purpose as in the snake.** |
| 4. Note the row of squared black spots down the middle of the back, arranged in zigzag fashion. | | **These spots help to distinguish it from the common snake.** |
| **TEETH.** | | |
| 1. Note shape of head; it is triangular, being very flat at the back and broad at the base. Compare with the snake's head. | The poison is contained in a large gland on each side of the back of the head, and then passes into a bag (the poison bag, until it is wanted. From the bag, a thin tube passes into the fangs, which are hollow, and have a little opening near the point. The fangs are not fixed in the jaw like the other teeth, and so, when the viper strikes its prey, these loose-fitting fangs are pushed back against the bag, the poison is forced through the thin tube into the fang, and so finds its way out through the little opening at the end into the wound of the victim. Sometimes when an animal is bitten it struggles, and breaks or tears away these brittle fangs, but there are always other fangs growing behind to take their places. | |
| 2. Note that the upper jaw bones are smaller than in the snake. Tell the class that the jaws can be moved up and down. | | |
| 3. Tell that there are teeth all over the mouth, even in the palate (two rows). | | |
| 4. Put sketch on B.B. showing fangs (fig. 129). The fangs are thin, sharp, and bent inwards. You can almost see through them; and they are placed on each side of the upper jaw. The fangs break easily, and there is no poison in them. | | **The fangs and poison glands are for defence.** |
| 5. Draw fig. 130 on B.B. showing narrow tubes in fangs. | | |

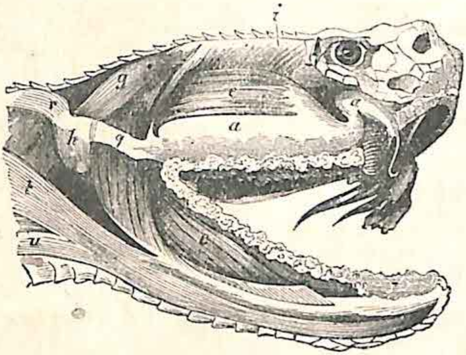


FIG. 129.—Poison apparatus of rattlesnake. *a*, poison bag and duct; *c*, *i*, *g*, *t*, *u*, muscles of jaw.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **WHY POISONOUS.** | | |
| 1. Note the size of the viper; it is a small animal. | The snake needs no fangs because it feeds principally on frogs, which cannot defend themselves, and which are easily swallowed because of their skin. | |
| 2. Tell what its food consists of: small animals, like birds, mice, &c. | | These animals might show fight because of the small size of the viper, hence the necessity for its fangs to make them powerless. |

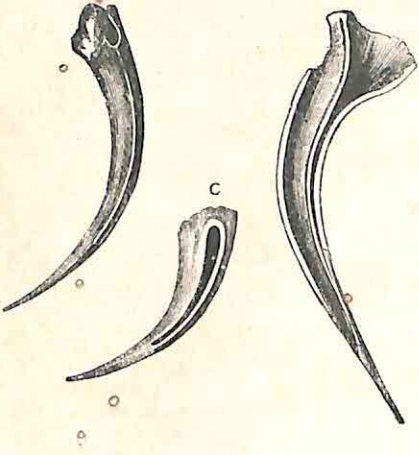


FIG. 130.—Poison fangs, showing their internal hollows. A, superficial view of fang; B, longitudinal section of fang; C. tooth with open poison groove.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. Tell that the poison, to be dangerous, must be introduced directly into the blood. | The poison of all venomous snakes can be swallowed without harm, because then the poison finds its way into the blood indirectly. | **Hence there is no danger in sucking poison from a wound.** |
| 4. Sketch the mouth of the viper and show its tongue (fig. 128). | This is merely the feeler of the viper, and is perfectly harmless. | |

## COMMON ERRORS.

Explode these by some recapitulatory questioning.

1. Snakes do not sting to death.
2. They are not always lying in wait ready to attack people.
3. Their breath is not poisonous.
4. They are nasty, slimy things, only when an untamed snake is handled.
5. They do not cover their food with slime before swallowing it.
6. The 'stings' of snakes do not lie in their tongues.

### COMPARATIVE SUMMARY.

The B.B. notes should be condensed from this summary.

| SNAKE | VIPER (ADDER) |
|---|---|
| 1. Longer (3 feet). | Shorter (18 to 20 inches). |
| 2. Slender, tapering head. | Flat, triangular head. |
| 3. No V on the head. | V on the head. |
| 4. Yellow patches on neck. | Ground colour of scales varies. |
| 5. Black spots on skin. | Zigzag patches on skin. |
| 6. Found in damp places, hedges, and ponds. | Found in woodlands, on dry heaths, and sandy wastes. |
| 7. Sleeps all the winter. | Sleeps all the winter. |
| 8. Both jaws and palate have rows of conical teeth. | No conical teeth in upper jaw; two rows of teeth on palate. |
| 9. No poison fangs. | Poison fangs. |
| 10. Upper jaw bones immovable. | Upper jaw bones smaller, and can be moved up and down. |

Drawing and composition to follow.

# STANDARD III

## MOISTURE IN AIR.

**Things required.**—*Towel, fire, scales, kettle; saucer full of water, placed in room some hours previously; seaweed hung in schoolroom; solid caustic soda, two flasks, spirit-lamp; fresh leaves inside clean corked flask; candle.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. Weigh wet towel, dry before fire, weigh again. | Second weight less than first. | **Water has not soaked into towel.** |
| 2. (*a*) Boil kettle; observe what happens to steam.<br>(*b*) Leave saucer full of water some hours in schoolroom. | Water disappears in air. | **Air can absorb (or suck up) water.**<br>[Cf. solution of salt in water.] |
| 3. (*a*) Hang seaweed in schoolroom; note condition from time to time. | Seaweed sometimes feels damp. | **Air contains water, which cannot be seen.** |
| (*b*) Bring glass of cold water into warm room. | *Outside* of glass covered with water. | |
| (*c*) Expose solid caustic soda to air. | Soda becomes wet. | |
| 4. (*a*) Have ready flask of boiling water; take another empty flask, heat over spirit-lamp (turning about to prevent cracking); invert second flask over flask of boiling water; cork second flask, continue to warm it over flame. | Nothing can be seen in second flask. | **Water vapour is invisible. The water in the air must exist in the form of water vapour.** |
| (*b*) Cool flask; wipe *outside* of flask. | Little drops of water form inside flask. | **Hot air can hold more water vapour than cold air.** |
| (*c*) Place cold slate in 'steam' of kettle (fig. 131). | Slate becomes moist. | **Cold causes water vapour to return to water.** |

| Observations and Experiments | Results | Inferences |
|---|---|---|
| 5. (*a*) Cork fresh leaves in clean flask for a few hours.<br>(*b*) Invert tumbler over burning candle.<br>(*c*) Breathe on slate. | Moisture is deposited inside flask.<br>Tumbler becomes dimmed with moisture.<br>Moisture deposited. | **Water vapour in air comes from:**<br>**1. Drying up of water.**<br>**2. Vegetation.**<br>**3. Burning.**<br>**4. Breathing.** |

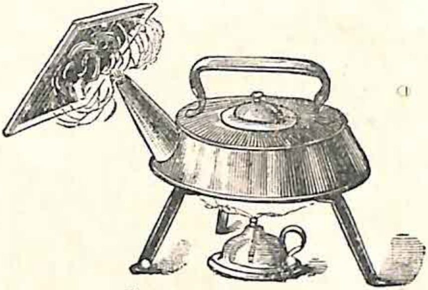


FIG. 131.—Kettle, &c.

B.B. SKETCH.

**Air contains water as invisible water vapour.**
**Hot air can hold more vapour than cold air.**
**Water vapour in air comes from:**

1. **Drying up of water.**
2. **Vegetation.**
3. **Burning.**
4. **Breathing.**

## DRAUGHTS IN ROOM.

**Things required.**—*Candle, long strips of thin paper, brown paper, bellows, lamp chimney, matchboxes, flasks, spirit-lamp, corks, water.*

NOTE.—*This Lesson will be most effective if given in winter-time.*

| Observations and Experiments | Results | Inferences |
|---|---|---|
| 1. Blow with bellows against pieces of paper. | The paper moves. | **Air moves things.**<br>**Air itself moves.** |
| 2. (*a*) Place lighted candle at bottom of closed door or near keyhole of door of classroom.<br>(*b*) Let child place hand at bottom of door.<br>(*c*) Place lighted candle near window.<br>(*d*) Feel air entering at window. | The candle-flame is blown inwards.<br>The hand becomes cold.<br>The candle-flame is blown inwards.<br>The air feels cold. | **Air is moving in at door.**<br>**The air moving in at door is cold air.**<br>**Cold air is also moving in at window.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. (*a*) Hold long strips of thin paper near fire. | The paper is blown towards the fire. | **The air is moving out of the room up the chimney.** |
| (*b*) Note direction of flames of burning fire. | The flames go straight up in the direction of the chimney. | |
| (*c*) Let child place hand some distance above fire.<br>(Draw a sketch like fig. 132 on B.B.) | Hand feels warm. | **The air moving up the chimney is warm air.** |
| 4. (*a*) Set lighted candle in lamp chimney which is slightly raised by being placed on two matchboxes (fig. 133). Place smoking brown paper below lamp chimney. | The smoke rises up the lamp chimney. | **The air enters at the bottom of the lamp chimney, becomes heated by the candle, and rises to the top of the chimney.** |
| (*b*) Let child place hand below and above lamp chimney. | The air at top of chimney is warmer than air below. | |
| 5. (*a*) Weigh flask and well-fitting cork; remove cork; heat flask well by constantly turning it in flame (to prevent cracking); cork immediately; weigh again; *or*, if the scales are not sufficiently sensitive, | Second weight is lighter than the first. | **Hot air is lighter than cold air.** |
| (*a'*) Weigh flask full of cold water; weigh same flask full of hot water. | Second weight is lighter than the first. | **Just as hot water is lighter than cold water, so hot air is lighter than cold air.** |

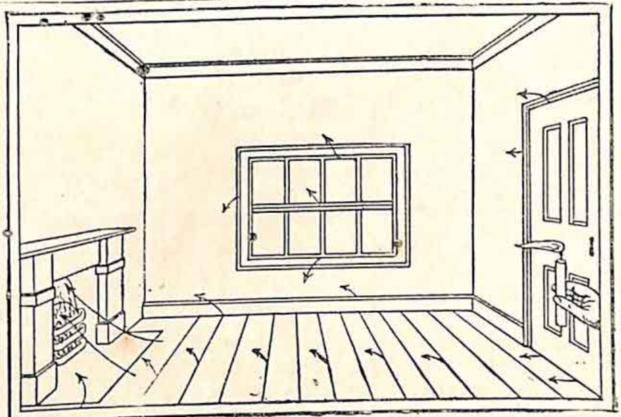


FIG. 132.—Natural ventilation. Air entering through the crevices between the floor-boards and window and door frames, and leaving by the chimney. A candle-flame near the door is deflected by the draught (after Teale).

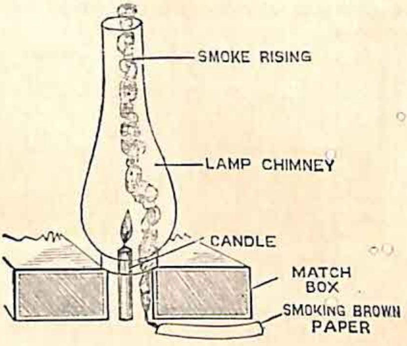


FIG. 133.—Lamp chimney, &c.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 6. Review whole Lesson, and apply knowledge to draughts in room. | | **Heavy cold air moves into room through doors and windows; light warm air leaves room by means of chimney.** |

B.B. SKETCH.

**Draughts.**

**Doors and windows let in air which is cold and heavy.**
**Chimneys let out air which is warm and light**

## DRAUGHTS IN ROOM, AND WINDS.

**Things required.**—*Scales; a large glass tumbler divided by a wooden or stiff cardboard partition which fits accurately, and which has been well greased at the edges, so that the glass is divided into two practically water-tight compartments; small flask, water, spirit or oil, colouring matter.* (*This apparatus will be somewhat difficult to prepare, but it is essential for the clear comprehension of the main point of this Lesson.*)

1. (*a*) Fill small flask full of cold water (coloured blue); weigh it; pour into compartment marked A.

(*b*) Fill same flask full of oil or methylated spirit (coloured red); weigh it; note that it is lighter than the water; pour into B. Draw special attention to the fact that A contains the heavy water, B the lighter oil or spirit.

(*c*) Carefully remove the partition. The heavy water, A, spreads along the bottom of the vessel, forcing the lighter spirit or oil, B, upwards.

Argue that in the same way heavy air will push light air upwards. (Carefully guard against the common error of stating that hot air rises, and *that cold air comes in to supply its place.*)

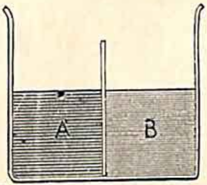


FIG. 134.

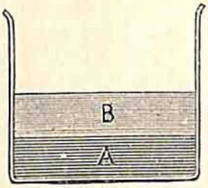


FIG. 135.

2. Refer to Experiment 4 (*a*) in previous Lesson, and get children to reason that the air inside the lamp chimney is hot and light, and that the colder, heavier air outside forces the lighter air upwards.

3. Extend the argument to the draughts in the room, and get children to reason that **the heavy cold air outside the room forces its way into the room, and forces the lighter warm air up the chimney.**

4. Compare sun with fire in room or with burning candle. Obtain from children's experience of sunshine and shade that sun does not warm all parts equally; consequently some air is hot, other air cold. Argue that **the cold heavy air forces the lighter warm air upwards.** *This motion of air is termed* **wind.**

NOTE.—*The varying directions of the wind can be noted from day to day, and after a time the winds can be classified as cold or warm, wet or dry, winds.*

## CLOUDS.

OUTDOOR OBSERVATIONS.—*This Lesson should preferably be given in the spring or early summer. For several days previous to the Lesson the children should be encouraged to observe the state of the sky on going to and returning from school. Each day the teacher should question the children as to the results of their observations, which might be summarised and written on the B.B.*

1. *After a suitable interval the class should be led to classify as follows* :—

   (*a*) '*Heap*' *clouds*—indicated in fig. 136 by *three* birds.
   (*b*) '*Bed*' *clouds*—indicated in the figure by *two* birds.
   (*c*) '*Feather*' *clouds*—indicated in the figure by *four* birds.
   (*d*) '*Rain*' *clouds*—indicated in the figure by *one* bird.

   A diagram showing each variety of cloud could be easily produced on B.B.

2. The main points in the Lessons on 'Steam' and 'Moisture in Air' should be recapitulated, special importance being attached to the following points :—

   (*a*) **Heat can convert water into water vapour, which is invisible.**
   (*b*) **Hot air can hold more water vapour than cold air.**
   (*c*) **On cooling, the water vapour becomes visible as little drops of water.**

Care should be taken to distinguish between the air and the water vapour the air contains. Compare the former to a sponge, the latter to the water the sponge sucks up.

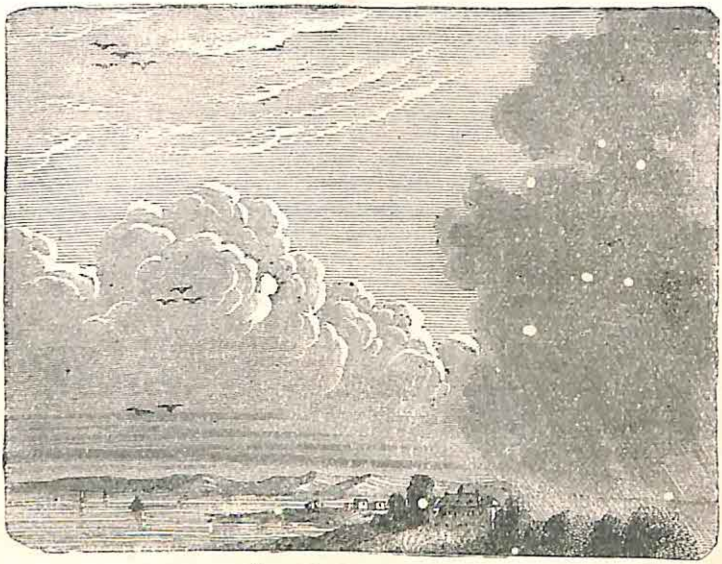


FIG. 136.—Varieties of clouds.

3. Draw attention to the steam issuing from spout of boiling kettle. Recall steam issuing from railway-engine. Compare steam from kettle and cloud in sky as follows :—
   (*a*) Both are white.
   (*b*) Both have a more or less curly shape.
   (*c*) Both are light, and float in air.

Remind children that they have learnt that what we call steam is really water vapour coming back to water, and deduce that **a cloud is made up of little drops of water.**

4. Get class to give the outlines of the theory of the formation of clouds (see B.B. Sketch below), and write down the main points as shown in B.B. Sketch.

### B.B. SKETCH.

### Clouds.

Kinds of Clouds :—

1. Heap
2. Bed
3. Feather
4. Rain

} Clouds.

A Cloud is made up of little drops of water.

The way Clouds are made :—

1. Heat of sun turns water into water vapour.
2. Water vapour rises in air.
3. Air becomes cold, is not able to hold so much vapour, some of which turns into little drops of water, which form a 'cloud.'

## RAIN.

**Things required.**—*Candle, several sheets of thin paper, kettle of boiling water, slate (if necessary); thistle-head, containing ripe thistle seeds; water, small stick, dusty slate.*

*This Lesson should be given during or immediately after a shower of rain. The facts in the left-hand column are supposed to have been observed by the children.*

| THINGS OBSERVED | EXPLANATIONS AND TEACHING HINTS |
|---|---|
| 1. *Previous to rain.*<br>(*a*) Absence of sun.<br>(*b*) Presence of black-looking clouds. | The clouds are so numerous and so thick that they hide the sun. As an illustration show that light of candle can be seen through single sheet of thin paper, but not through several sheets. |
| 2. *During rain.*<br>(*a*) Rain falls from above. | Recapitulate Lesson on Clouds. If necessary, again condense steam from kettle by putting cold slate into it (Lesson on Moisture in Air, 4 (*c*) p. 137). Explain that a hill might act like the slate. Make a diagrammatic sketch of 'Clouds striking the hills and falling as rain' (fig. 137).<br>Explain the suspension of water particles in clouds and the descent of raindrops as follows:<br>Take thistle-head; show that it drops easily through the air. Break case enveloping seeds and let them escape; note that they float in air. Argue that water particles in clouds are so light that air can support them, but when several particles run together and form a raindrop, the drop becomes so heavy that the air can no longer support it. Get children to go through in order the stages in the formation of rain as shown in B.B. sketch. |
| (*b*) Rain drops are round. | Illustrate as follows:—<br>(*a*) Dip stick into water; remove stick; note that the water collects at the end in a longish drop, then falls from stick, and becomes quite round in its course through the air.<br>(*b*) Drip water on to dusty slate, and note round holes in dust.<br>(*c*) Tears run down cheeks in long streams; when they fall from cheeks they become round.<br>Deduce that raindrops become rounded in their passage through the air. |

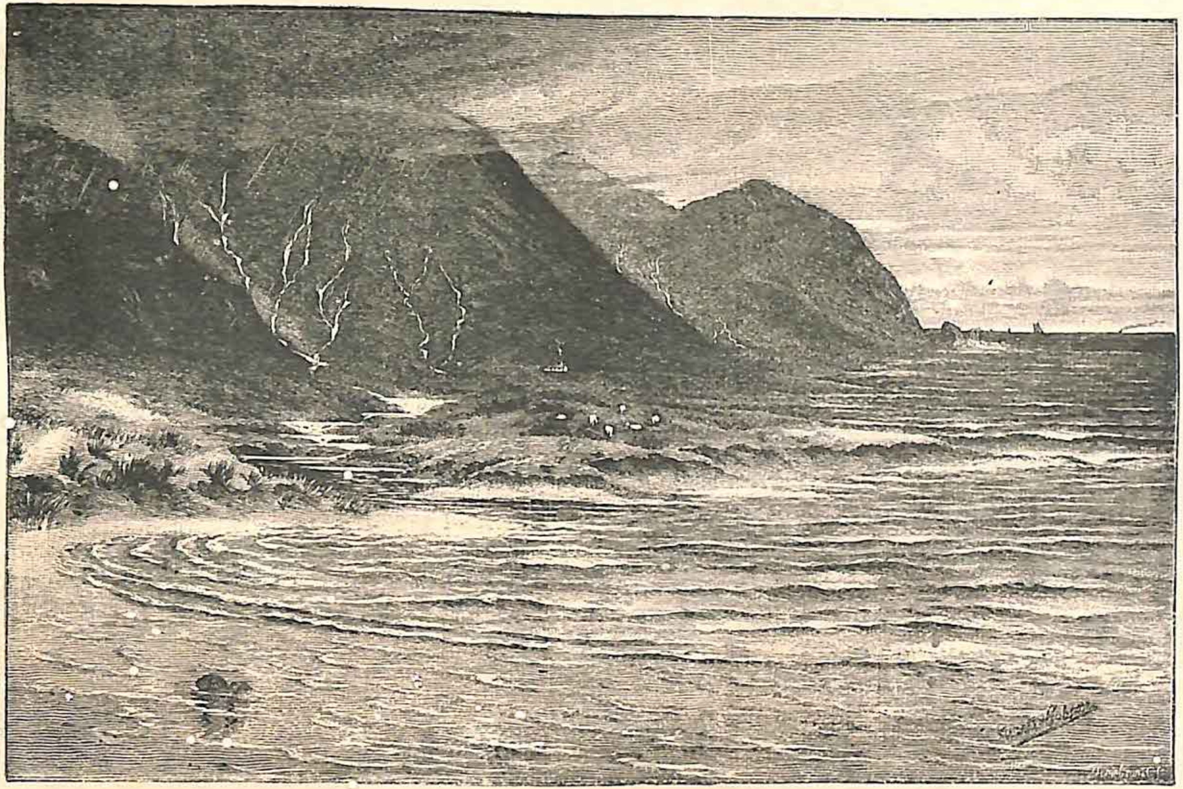


FIG. 137.—Clouds striking the hills and falling as rain.

| THINGS OBSERVED | EXPLANATIONS AND TEACHING HINTS |
|---|---|
| 3. *After rain.* | |
| (*a*) Small round holes in ground; seen only after slight shower. | This is apparent from 2 (*b*). |
| (*b*) Channels made by rain-water running over road or garden. | An elementary idea might be given of the effects of rain in altering the surface of a country. |
| (*c*) Stones, &c., washed some distance after heavy rain. | |

NOTE.—*Several highly useful exercises in weather observation can be made to follow this Lesson*, e.g. :—1. *A record might be kept for some time of the direction of the wind and the state of the weather. Thus the rainy winds of the district may be ascertained.* 2. *A rain-gauge can be easily made by getting a tin canister, piercing a hole in the lid, and inserting the neck of a funnel of the same diameter as the canister* (*fig.* 138). *It can be placed in the playground, or, better still, on the roof of the school. It can be examined daily, and the amount of rain water in it can be registered.*

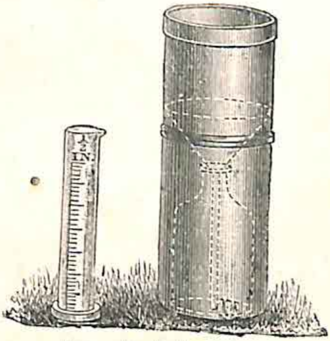


FIG. 138.—Rain-gauge.

### B.B. SKETCH.

**Cause of rain :—**

1. **Air containing watery vapour strikes against cold hill.**
2. **Air becomes cold and cannot hold so much watery vapour.**
3. **Some gets turned into water particles, which form a cloud.**
4. **The water particles run together, become too heavy for the air to hold up, and fall as rain.**

## DEW.

**Things required.**—*Glass of cold water, kept outside room; flask of boiling water, clean flask, spirit-lamp, two teacups, and teapot cosy.*

*This Lesson should be given in spring or summer time.*

1. Draw attention to boots of child who has walked through meadows on the way to school. Ask for reason of dampness.
2. Repeat Experiment 3 (*b*), Moisture in Air, p. 137. Compare moisture on glass with dew on grass. Infer that **dew is water that has come from watery vapour in the air.**

3. Repeat Experiment 4 (*a*), Moisture in Air, p. 137, and note that the colder the flask becomes the more moisture or dew is deposited on the inside.
4. Go through with children the reason for the formation of dew.
   - (*a*) *What happens to water, air, &c., whilst sun is shining?* Air becomes warm; warm air is able to hold more watery vapour than cold air (Moisture in Air, 4 (*b*), p. 137), and consequently absorbs much watery vapour from vegetation, ponds, &c.
   - (*b*) *State of air, grass, &c., at sunset.* Air and grass are warm; air is holding much watery vapour.
   - (*c*) *State of air and grass after sunset.* Grass cools; air above it cools, consequently is not able to hold so much watery vapour (Moisture in Air, 4 (*c*), p. 137), some of which is deposited as **dew.**
5. Ask children to notice during next few evenings the following points:—
   - (*a*) *Where* they notice more dew—on grass or on road?
   - (*b*) *When* they notice more dew—on a cloudless or a cloudy night?
6. After a suitable interval return to subject, obtain answers, and proceed as follows:—
7. *More dew is found on grass than on road.* Therefore, from previous knowledge, argue that grass must have become colder than the road.
8. *More dew is found on a cloudless than a cloudy night.* Take two teacups, (1) and (2); pour boiling water into each. Cover (1) with tea-cosy, leave (2) uncovered. After lapse of half an hour note that (2) is colder than (1). Cosy has prevented heat escaping from teacup (1), and argue that in same way **clouds prevent heat escaping from earth, and objects on earth do not become cold enough to cool air above, and favour formation of dew.**

### B.B. SKETCH.

**The way Dew is formed.**

1. **Whilst sun shines air absorbs much watery vapour.**
2. **When sun sets, grass cools; air above it cools, and is not able to hold so much watery vapour, some of which settles on the grass as dew.**

## SNOW.

**Things required.**—*Snow in pail, loaf sugar, chalk, sheets of paper, fire.*

*This Lesson should be given in snowy weather.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Ask children for colour of snow; compare with loaf sugar, contrast with chalk. | Snow is white. It sparkles much like sugar. | **Sugar sparkles and is composed of crystals, therefore snow is composed of crystals** (fig. 139). |
| (*b*) Let child feel snow. | Hand feels cold. | **Snow is cold.** |
| 2. (*a*) Try to squeeze snow in hand. | Snow easily squeezed. | **Snow is soft.** |
| (*b*) Make snow into a snowball, press very hard; cut snowball into halves. | A hard core of something like ice is found inside. | **Snow when pressed becomes ice.** |
| (*c*) Ask boys which is harder to clear away—the top or bottom of a snowdrift. | The bottom is 'caked,' and therefore harder to clear away. | **The pressure of snow above hardens the snow below.** |

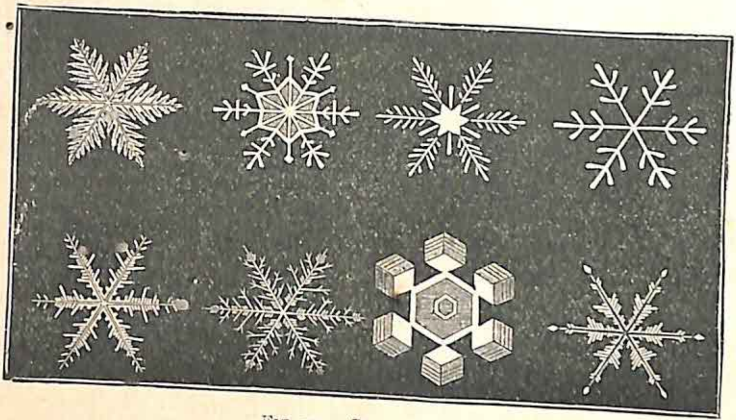


FIG. 139.—Snow crystals.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. (*a*) Take pail full of snow; melt it before fire. | Only a little water is left in bottom of pail. | **Snow takes up more room than water.** |
| (*b*) Contrast fall of snow with fall of rain. | Snow falls slowly; rain quickly. | **Snow was formed from something lighter than water.** |
| 4. Note frost on inside of window-panes.<br>(From Lessons on Moisture in Air and Dew argue that this frost is frozen watery vapour.)<br>Compare frost on panes with snow. | They are both alike in being made up of crystals. | **Frost on panes is composed of crystals, and is formed from watery vapour. Snow is composed of crystals, and is formed from something lighter than water. Watery vapour is lighter than water. Hence snow is probably formed from frozen watery vapour.** |

## B.B. SKETCH.

Snow.

White; made up of crystals.
Cold.
Soft
When pressed becomes ice.
Is formed from frozen watery vapour.

# PRESSURE OF THE AIR.

**Things required.**—*Tumbler, stout paper, tin can with holes in bottom* (fig. 141), *flask, thin paper, cotton, spirit-lamp, pickle-jar, half of a hard-boiled egg a little larger than mouth of pickle-jar.*

| Observations and Experiments | Results | Inferences |
|---|---|---|
| 1. (*a*) Fill tumbler with water; cover with stout paper; place palm of hand on paper; carefully invert glass. | The paper does not fall away; the water does not run out (fig. 140). | **Air presses upwards.** |
| (*b*) Fill tin can (fig. 141) by immersing it in pail of water; place thumb on hole in cork; still keeping thumb on cork, remove can from water. | The water does not run out through holes in bottom of can. | |
| 2. (*a*) Remove thumb from hole. | Water runs out (fig. 141). | **Air presses downwards.** |
| 3. (*a*) Tie thin paper over mouth of flask; heat flask. | The paper is forced upwards. | **When an open flask is heated some of the air is driven out of the flask.** |
| Remind children of Experiment of heating a bladder partly filled with air (p. 88). | | |
| (*b*) Introduce pickle-jar; place half of a hard-boiled egg on mouth. | The egg does not fall into the jar. | |
| (*c*) Remove egg; ignite paper, plunge into jar, replace egg. | The egg is forced into the jar. | **The air, in trying to get back into flask, has pushed egg into jar.** |
| (*d*) Take same jar, plunge ignited paper into jar; let boy place palm of hand over mouth of jar. | The boy feels that his hand is being pressed into the jar. | **Air presses downwards.** |

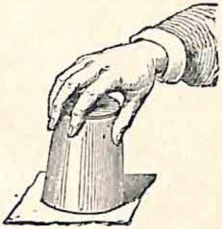


FIG. 140.

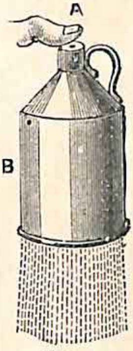


FIG. 141.

| Observations and Experiments | Results | Inferences |
|---|---|---|
| 4. Repeat Experiment 3 (*c*), holding jar sideways. | The egg is forced into the jar. | **Air presses sideways.** |
| 5. Review Lesson on Pressure of Water (p. 93), dwelling especially upon the fact that water was shown to press *equally* in all directions. | Air and water are alike as regards pressing upwards, downwards, and sideways. | **Air, like water, presses equally in all directions.** |

B.B. Sketch.

**Air presses upwards }**
**downwards } like water does.**
**sideways }**
**Air (like water) presses equally in all directions.**

## BOY'S SUCKER AND SQUIRT.

**Things required.**—*Boy's sucker* (*too familiar to need description*), *knife*, *boy's squirt*, *glass syringe*, *coloured water*.

| Observations and Experiments | Results | Inferences |
|---|---|---|
| 1. Place moist sucker on schoolroom hearthstone; press sucker down with foot. | The sucker lies quite flat on the hearthstone. | **There is little or no air between the hearthstone and sucker.** |
| 2. Gently pull string upwards (fig. 142). | The middle of the sucker comes up, the sides remain attached to hearthstone. | **There can be little or no air contained in the arched part of the sucker** (fig. 144). |
| 3. Pull string upwards with greater force. (Recall Lesson on Pressure of Air, p. 148.) | The sucker cannot be lifted. | **The sucker cannot be lifted because the air presses downwards with greater force than the force with which the string is pulled upwards.** |
| 4. Insert knife between edge of sucker and hearthstone. | The sucker can now be easily lifted. | **The pressure of air upwards on the sucker has become equal to the pressure of the air downwards. Only the weight of the sucker has now to be lifted.** |

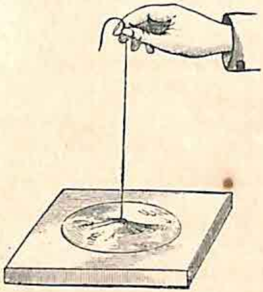


FIG. 142.

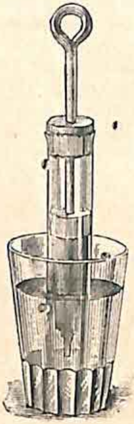


FIG. 143.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 5. Show boy's squirt and glass syringe. Take them to pieces; compare and contrast. | Both have a barrel, nozzle, piston and rod; we can see what is inside the glass syringe. | **The glass syringe is better to work with in the Lesson because we can see what goes on inside it.** |
| 6. Place nozzle of syringe in glass of coloured water (fig. 143); pull piston. | The water rises in the syringe. | **Pulling the piston backwards pulls out the air. The pressure of the air on the water in the tumbler is now greater than the pressure of the air inside the syringe, and some of the water in the tumbler is pushed up into the syringe.** |
| 7. Hold syringe by piston-rod; remove it from water; allow it to hang downwards. | The water does not flow out. | **This is another proof that air presses upwards.** |
| 8. Place finger on nozzle of syringe; try to push down piston. | The piston can be pressed a little way only, if at all. | **It is very hard to press water into a smaller space.** |
| 9. Remove finger; press piston. | The water spurts out. | **The water spurts out because it resists being pressed.** |

B.B. SKETCH.

**Sucker.**

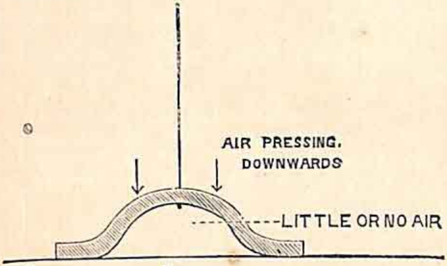


FIG. 144.

**Syringe.** 1. Barrel—Nozzle.
2. Piston—Plug.

**Pressure of air forces water into syringe.**
**Water spurts out because water resists being pressed.**

## POPGUN.

**Things required.**—*Popgun, bladder, syringe with tightly fitting piston, paper bag.*
**Introduction.**—*Review previous knowledge on pressure of air.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Take bladder filled with air; squeeze it gently.<br>(*b*) Cover nozzle of syringe with finger; press piston down. | The bladder is easily squeezed.<br>The piston can be pressed down some distance. | **Air is easily pressed into a smaller space.** |
| 2. (*a*) Again press bladder, and this time note what happens when pressure is removed.<br>(*b*) After pressing piston down, as in 1 (*b*), note what happens on removal of hand pressing down piston. | The bladder returns to its original shape.<br>The piston-rod rises upwards. | **But on the removal of the pressure it returns to its former size, thus showing that air is elastic.** |

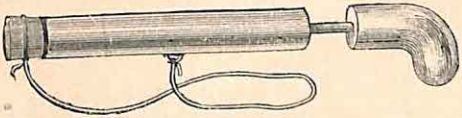


FIG. 145.

| | | |
|---|---|---|
| 3. Introduce popgun (fig. 145). Take it to pieces; name and describe parts. | The parts are: tube with loose cork, and rod with cork attached. | |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 4. (*a*) Work the pop-gun.<br>(*b*) Measure lengths of rod and tube. | Loose cork is forced out.<br>The rod is shorter than the tube. | **The cork attached to rod did not touch loose cork, and yet pushed it out.** |
| 5. (*a*) Squeeze bladder tightly.<br>(*b*) Fill paper bag with air; hold open end tightly to prevent outrush of air; strike with palm of hand. | Both the bladder and the bag burst with loud reports. | **When air is pressed very much it tries so hard to occupy its former space that it will break things in its efforts to do so.** |
| 6. (*a*) Introduce popgun once more; note distance between two corks; gently press rod.<br>(*b*) Press rod down sharply. | There is less space after than before.<br>The cork flies out. | **The air in the tube must be pressed.**<br>**The air inside becomes pressed too hard, and in trying to regain its former size presses out the loose cork.** |

B.B. SKETCH.

**Popgun.**

**Parts.**

1. **Tube with loose cork.**
2. **Rod with cork attached.**

**How it acts.**

1. **Pressing the rod presses the air in tube.**
2. **But air is elastic, and tries to occupy its former space.**
3. **In doing so, the air pushes out the loose cork.**

## CHALK AND LIME.

**Things required.**—*Chalk; fire, or Bunsen burner, and blowpipe; quicklime, water, scales, sand.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Take piece of chalk; weigh it; heat in crucible in Bunsen flame; weigh again; or,<br>(*b*) Place piece of chalk in strongly burning fire for three or four hours previous to Lesson; take out of fire. Compare with chalk as regards colour and hardness. | The second weight is lighter than the first.<br>The chalk is white, and does not crumble very easily. The chalk, after heating, is a yellowish white, and crumbles easily. | **The heat has driven something out of the chalk.**<br>**The heat has altered the character of the chalk.**<br>[Tell the name—*Quicklime.*] |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 2. Take a small piece of the quicklime; place in a bottle of water; note results; shake up.<br>Contrast with chalk. | The quicklime makes a hissing noise when it meets the water, and after a time the whole of it disappears. | **Quicklime is soluble in water.**<br>(Teach the name—*Lime water*.) |
| 3. Place a lump of quicklime in saucer. | | |
| (*a*) Add a drop or two of water. Compare with chalk. | The water disappears in the quicklime. | **Quicklime easily absorbs water.** |
| (*b*) Continue to drop water on piece of quicklime. Contrast results with chalk under similar conditions. | The quicklime begins to smoke, becomes hot, and cracks. | **When quicklime absorbs water heat is produced.** |
| (*c*) Add a little more water.<br>(Teach the name *slaked lime*, and show the appropriateness of the term *slaked*.) | A *powder* is produced which is quite dry. | |
| 4. Add a little slaked lime to water; note results. | There is no hissing noise, but the slaked lime dissolves. | **Slaked lime is different from quicklime.** |
| 5. (*a*) Add more water to quicklime than was added in 3 (*c*). | A paste is formed, which 'sets' readily. | **A mixture of quicklime and water would be useful for sticking things together.** |
| (*b*) Let child feel the paste. | It is 'sticky.' | |
| 6. Make a mixture of quicklime, sand, and water. | Another paste is formed, which 'sets' readily. | **Mortar is a mixture of quicklime, water, and sand.**<br>(The uses of mortar can now be pointed out.) |

## B.B. SKETCH.

**Chalk + Heat = Quicklime.**
**Quicklime + Water = Slaked Lime.**

| Chalk. | Quicklime. | Slaked Lime. |
|---|---|---|
| White solid. | Yellowish solid. | Yellowish powder. |
| Insoluble in water. | Soluble in water. | Soluble in water. |
| Absorbs water without production of heat. | Absorbs water with production of heat. | Forms a paste with water without production of heat. |

Mortar is a mixture of Quicklime, Sand, and Water.

## CARBONIC ACID GAS (FIRST LESSON).

**Things required.**—*A pickle-jar with cork fitted with a thistle funnel and bent tube* (*a more elaborate form of the apparatus is shown in fig.* 146) *; chalk ; any acid* (*vinegar will do*) *; water, several glass jars, quicklime, candle mounted on wire, scales, spirit lamp, saucer.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS. | INFERENCES |
|---|---|---|
| 1. (*a*) Place chalk in saucer ; pour a few drops of acid on it. | Bubbles are formed on the chalk. | **The bubbles must be gas.** |
| (*b*) Pour a few drops of acid on quicklime. | No bubbles are formed. | **This gas must have been driven off when the chalk was turned into quicklime.** |
| 2. (*a*) Place piece of chalk in glass jar ; lower lighted candle into jar. | The candle continues to burn. | |
| (*b*) Pour acid over chalk ; lower lighted candle. | The candle is extinguished. | **The gas given off is not air, for the candle will not burn in it; it is not coal-gas, for it does not take fire.** |
| (*c*) Again lower lighted candle, and note if the new gas burns.<br>(Teach the name Carbonic Acid Gas). | The new gas does not burn. | |
| 3. Fit up apparatus described in 'Things required' (fig. 146 shows a more elaborate form) ; before corking the bottle insert some chalk ; pour *dilute* acid through the funnel. | Bubbles are formed. | **Carbonic acid gas is being produced.** |

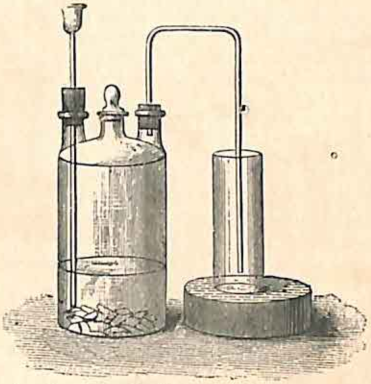


FIG. 146.—Apparatus for the preparation and collection carbonic acid gas.

| Observations and Experiments | Results | Inferences |
|---|---|---|
| 4. Lower lighted candle into the glass receiver. | The candle is extinguished. | **The receiver must contain carbonic acid gas.** |
| 5. (*a*) Ask children if they can *see* the gas in the receiver; compare with air and coal-gas.<br>(*b*) Let child *smell* the jar; compare with air, contrast with coal-gas. | The carbonic acid gas is invisible.<br>The carbonic acid gas has no smell. | **Carbonic acid gas, like air and coal-gas, is invisible.**<br>**Carbonic acid gas, like air, and unlike coal-gas, has no smell.** |
| 6. (*a*) Take jar (1), filled with carbonic acid gas. Test jar (2) with lighted candle to show that it contains no carbonic acid gas. Pour carbonic acid from jar (1) to jar (2) in the same way as water would be poured; again test jars;<br>or (*b*) Fit up the apparatus shown in fig. 147; balance the open glass vessel; pour in carbonic acid gas. | Jar (2) now contains carbonic acid gas; jar (1) has no carbonic acid gas.<br>The side containing the carbonic acid gas descends. | **Carbonic acid gas must be heavier than air, for it can be poured downwards.**<br>**Carbonic acid gas is heavier than air.** |
| 7. (*a*) Allow carbonic acid gas to bubble into water (fig. 148) for some time.<br>(*b*) Take the water used in (*a*), and gently heat it in a long glass vessel.<br>(*c*) Lower lighted candle into the vessel; do not allow it to touch the liquid. | The candle is extinguished. | **Carbonic acid gas is soluble in water.**<br>**The carbonic acid gas may be obtained from the water by heating it.** |

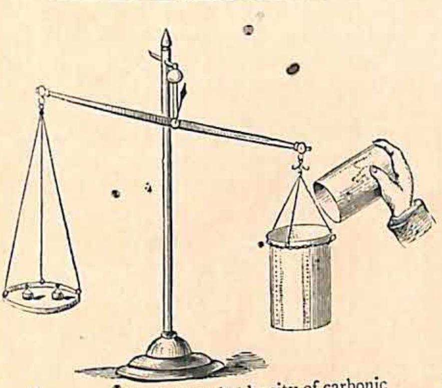


FIG. 147.—Illustrating the density of carbonic acid gas.

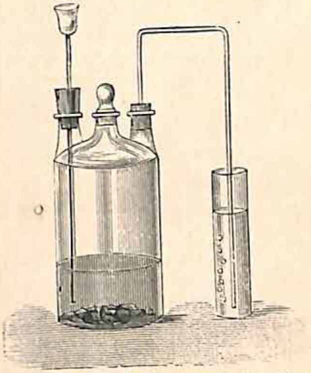


FIG. 148.—Showing how a solution of carbonic acid gas may be prepared.

B.B. SKETCH.

**Carbonic acid gas.**

Invisible.
No taste, no smell.
Does not burn.
Puts out candle.
Heavier than air.
Soluble in water.

## CARBONIC ACID GAS (SECOND LESSON).

**Things required.**—*Two or three glass jars filled with carbonic acid gas, several empty jars, clear lime water, candle, evaporating-dish, spirit lamp, jar containing coal-gas, bottle of lemonade or other mineral water.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Pour a little clear lime water into jar containing carbonic acid gas; shake jar.<br>(*b*) Allow the white powder to settle; pour off fairly clear liquid above.<br>(*c*) Pour the thick liquid below into an evaporating-dish; boil off the water. | The lime water is turned milky.<br>A white powder is left behind. | **The milkiness is caused by the formation of an insoluble white powder.** |
| 2. (*a*) Examine the residue.<br>(*b*) Rub some on B.B.<br>(*c*) Pour acid on the residue; hold match above.<br>(*d*) Recapitulate and bring out point 4 in B.B. Sketch. | It consists of white grains.<br>It marks like chalk.<br>A gas is given off, which extinguishes a light. | **The insoluble white powder is chalk.** |
| 3. (*a*) Pour lime water into a jar containing air.<br>(*b*) Pour lime water into a jar containing coal-gas. | Lime water does not turn milky.<br>Same result. | **We can distinguish between carbonic acid gas on the one hand, and air and coal-gas on the other, because carbonic acid turns lime water milky, the others do not.**<br>(Tell children that carbonic acid is the only thing that turns lime water milky.) |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 4. (*a*) Breathe through a tube into some lime water. | The lime water is turned milky. | **The air we breathe out contains carbonic acid gas.** |
| (*b*) Let saucer of clear lime water stand for some time in schoolroom. | A thin film of chalk forms on top. | **The air we breathe in contains a little carbonic acid gas.** |
| 5. Burn candle in a closed jar. When candle is extinguished, remove it, and pour in lime water. | The lime water is turned milky. | **A burning candle produces carbonic acid gas.** |
| 6. (*a*) Carefully open a bottle of lemonade or other mineral water; hold lighted match above bottle. | The lighted match is extinguished. | **The gas given off from lemonade, ginger-beer, &c., is carbonic acid gas.** |
| (*b*) Place the lemonade in flask, apply heat; collect gas (fig. 149); test with lime water. | The lime water is turned milky. | |

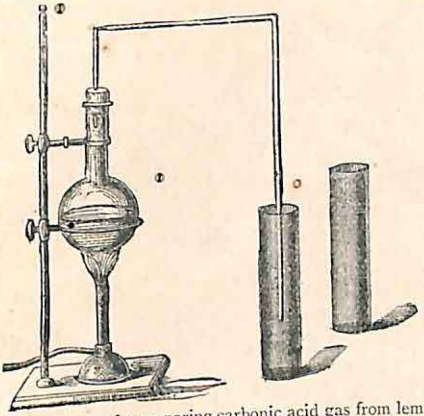


FIG. 149.—Apparatus for preparing carbonic acid gas from lemonade.

## B.B. SKETCH.

1. Carbonic acid gas turns clear lime water milky.
2. Chalk − carbonic acid gas = quick lime.
3. Quicklime + water = slaked lime.
4. Quicklime (in water) + carbonic acid gas = chalk
5. Air breathed out contains
   A burning candle produces
   Bottled lemonade, &c., contains } carbonic acid gas.

# DIFFERENCES BETWEEN WATER AND GASES.

**Things required.**—*This Lesson is mainly recapitulatory. The teacher should make arrangements for re-working two or three of the experiments which he has found most difficult for the class to understand. For new experiments the following will be necessary: Nitric acid, halfpenny, jar full of coal-gas.*

1. Recall, and if found necessary re-work, experiments showing that both air and water occupy space (Standard I. p. 19) and have weight (Standard II. p. 90).
2. Recall, and if necessary re-work, experiments showing that water (Standard I. p. 14) and carbonic acid gas (Standard III. p. 155) can be made to flow from one vessel into another. Infer that water, air, and carbonic acid gas are alike in these respects :—
   - (*a*) They both occupy space.
   - (*b*) They both have weight.
   - (*c*) They both can be made to flow.
3. (*a*) Recall the fact that water has a level surface (Standard I. p. 15).
   (*b*) Pour a little nitric acid over a halfpenny; note the absence of definite shape of the brown gas given off. It can be seen that the brown gas does not have a level surface. In the same way, the air coming in at the door and window does not have a level surface.

   **Water has a level surface; air has not a level surface.**
4. (*a*) Recall experiment showing that it is very hard to press water (Standard III. p. 150).
   (*b*) Recall experiment showing that air can be easily compressed (Standard II. p. 90).

   **Water is hard to compress; air is easily compressed.**
5. (*a*) Pour water on floor—it spreads itself out a little.
   (*b*) Turn gas on—it can soon be smelt all over the room, showing that it spreads itself out much more freely.

   **Water spreads out a little; coal-gas spreads itself out much more freely.**
6. (*a*) Recall experiments on pressure of water (Standard II. p. 92), and deduce that **water needs support at bottom and sides.**
   (*b*) Remove cover from jar of coal-gas; after a time smell jar for gas. All the gas has disappeared. Deduce that **coal-gas needs support on all sides.**
7. Recapitulate chief points, and draw up tables of similarity and dissimilarity between water on the one hand, and air, carbonic acid, &c., on the other, as shown in B.B. Sketch, and introduce the term **gas**.
8. Guard against the possibility of children thinking that all gases are colourless by drawing special attention to experiment in 3 (*b*).

### B.B. Sketch.

Air.
Carbonic acid gas.
Water. Coal-gas.

Occupy space.
Have weight.
Can be made to flow.

| Water. | Gases. |
|---|---|
| Has a level surface. | Have not a level surface. |
| Hard to compress. | Easily compressed. |
| Spreads out only a little. | Spread out freely. |
| Needs support at bottom and sides of vessel. | Need support on all sides of vessel. |

## A MAGNET.

Things required.—*A straight bar magnet, horseshoe magnet, several knitting needles, one at least magnetised; pen-nibs, nails, iron filings, silk thread, poker, shilling, penny, piece of brass, wood, sewing needles.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Take magnetised and ordinary knitting needles; plunge each into box of pen-nibs, iron filings, &c. | One needle picks up pen-nibs, iron filings, &c., the other does not. | **One needle has some power which the other needle has not.** |
| (*b*) Suspend each needle (fig. 150); allow each to oscillate and come to rest. Repeat several times. | One needle always comes to rest in *one* position, the other in *any* position. | (Teach the term *magnet*). |
| 2. (*a*) Take magnetised knitting needle; dip into iron filings. | The iron filings collect near the ends. | **The strength of a magnet seems to be at its two ends.** |
| (*b*) Try to take up pen-nib with *middle* of magnetised knitting needle. | The middle of the magnet will not take up the pen-nib. | |
| (*c*) Repeat with bar magnet (fig. 152). | | |

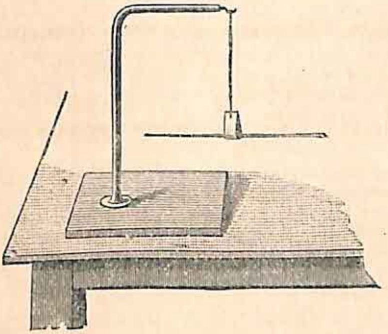


FIG. 150.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 3. Introduce horseshoe magnet (fig. 152); try to suspend it from poker, first with *one* end of magnet, then with *both* (fig. 153). | The magnet cannot always be suspended from one end, but can always be suspended from two ends. | **By bending a magnet into a horseshoe shape its power seems to be increased.** |
| 4. (*a*) Take an unmagnetised nail; try to pick up another nail. | The nail is not picked up. | |
| (*b*) Suspend nail from end of magnet; place another nail on end of first nail, &c. (fig. 154). | The second clings to the first. | **The magnet has made the first nail into a magnet; the first nail has made the second into a magnet, &c. But the nail is only a magnet as long as the original magnet is near it.** |
| (*c*) Remove magnet, and see whether first nail will support second. | The first nail does not support the second when the magnet is withdrawn. | |
| 5. The question will now arise, Can iron be made into a magnet which will retain its magnetism? | | |
| (*a*) Place needle on table; rub magnet along needle, *always beginning at the eye end of the needle and finishing at the pointed end.* See if needle will pick up pen-nib, &c. | The needle after being rubbed by magnet will pick up pen-nib, &c. | **It is possible to make a needle or steel bar into a permanent magnet.** |
| (*b*) Similarly magnetise steel bar (fig. 155). | | |

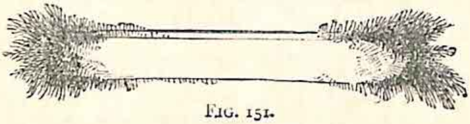


FIG. 151.

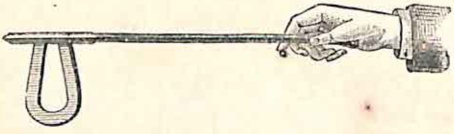


FIG. 153.

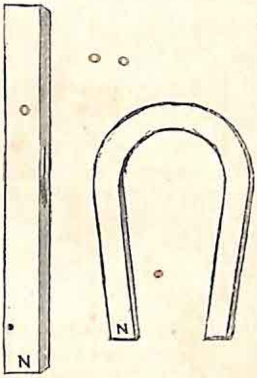


FIG. 152.

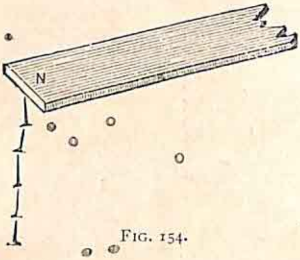


FIG. 154.

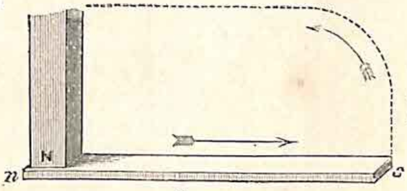


FIG. 155.

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 6. Try to pick up shilling, penny, brass, wood, iron, steel, &c., with magnet. | The magnet will pick up nothing but the iron and steel. | **Iron and steel are the only common things the magnet will pick up.** |

B.B. SKETCH.

**Magnet.**

**Picks up iron and steel.**
**Is strongest at its ends.**
**A piece of steel can be made into a magnet by rubbing it the same way with another magnet.**
**Iron and steel are the only common things a magnet will pick up.**

## THE COMPASS.

**Things required.**—*Magnetised knitting needles; silk thread, strips of blue and red paper, school compass, a small boat compass, or a card with magnetic needle below it balanced on a pivot.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Suspend magnetised knitting needle as in Experiment 1 (*b*) last lesson. Note position the needle takes up on coming to rest.<br>(*b*) Or float magnetised needle on cork in water. | One end of needle always points to north; other end to south.<br>[Attach red paper to end pointing north, blue paper to that pointing south; call ends the *north-seeking* and *south-seeking* ends respectively.] | **A freely suspended magnet always takes up a definite position, and points north and south.** |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| (*c*) Place bar magnet under suspended magnetised needle, taking care to put the south pole under the north-seeking end of suspended needle; gently move bar magnet. | The suspended needle follows the bar magnet. | **The bar magnet attracts the needle.** |
| (*d*) Place bar magnet east and west; allow magnetised needle to oscillate above it. | The needle comes to rest over the bar magnet. | **The earth must behave like the bar magnet.**<br>**The earth acts as a great magnet.** |
| 2. Remind class of the different ways they have learnt of telling which is the north. Ask how we should be able to tell the north in the absence of sun and stars. | | **The magnet is useful for telling the north.** |

3. Introduce the school compass, which nearly always has the needle suspended above the card. Show that the needle is a magnet, and how, when the north has been determined, the other points can be easily ascertained.

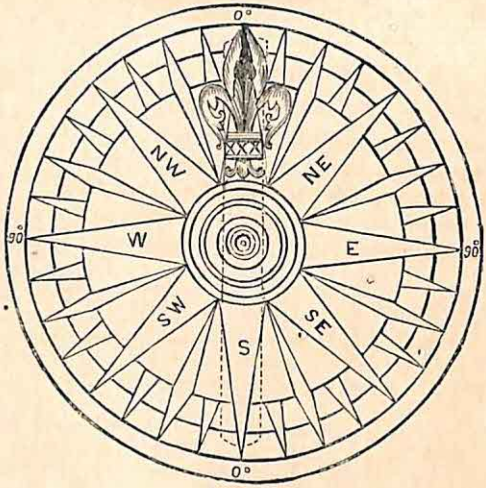


FIG. 156.

4. Show ship compass (or card with needle below it).
   (*a*) Tilt compass and show that it always remains horizontal whatever the position of the boat.
   (*b*) Draw attention to the line *d* (fig. 157), showing the direction of the keel of the ship.

(*c*) Contrast the use of the school compass and boat compass on board ship by supposing that the sailor is told to steer east. If he used a school compass, he would have to see which was the north and then calculate where the east would be; whereas with the boat compass he has merely to turn the ship until the point marked east is pointing to the line *d*, and he then knows the ship is going directly east.

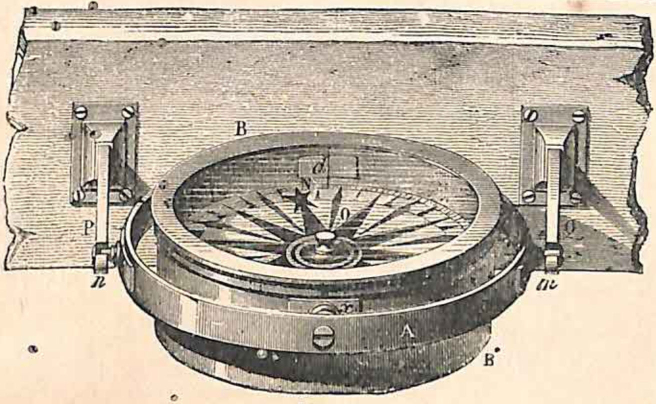


FIG. 157.

[*The children might be encouraged to make models of land and sea compasses.*]

B.B. SKETCH.

**Magnet points north and south.**
**The earth acts like a great magnet.**
**Land compass: Magnet movable; card fixed.**
**Sea compass or mariners' compass.} Magnet movable; card fixed to magnet and moves round with it.**

## A RIVER (FIRST LESSON).

OUTDOOR WORK.—In order that the maximum benefit may be obtained from the next two lessons the children should be taken to the nearest stream, and as many of the following points as possible should be observed:—

1. Water in stream flows.
2. Water flows faster in middle than at sides; faster on outer than on inner bend. (This can be shown by noting corks or pieces of paper thrown into stream.)
3. The winding of the stream. Attention should be drawn to rocks, &c., which prevent a straight flow (figs. 158, 160).
4. Stream widens in direction of flow and is joined by water courses from fields. Note any deposition of sand at confluence.
5. In the quickly moving parts beds of pebbles are found; in the less rapidly moving portions, beds of gravel; in the comparatively still portions, beds of sand.
6. The size, shape, and arrangement of pebbles should be noted, also similarity to or dissimilarity from surrounding rocks. Characteristic specimens should be labelled and carried away.
7. Several bottles of water should be brought away.

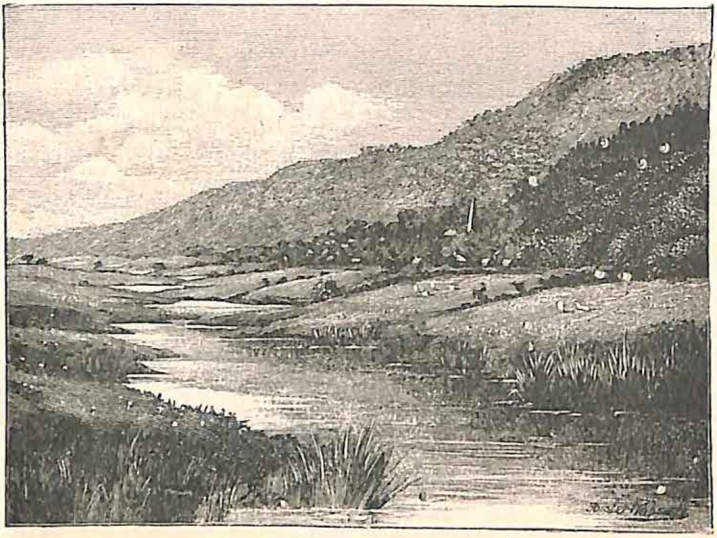


FIG. 158.—The middle course of a river.

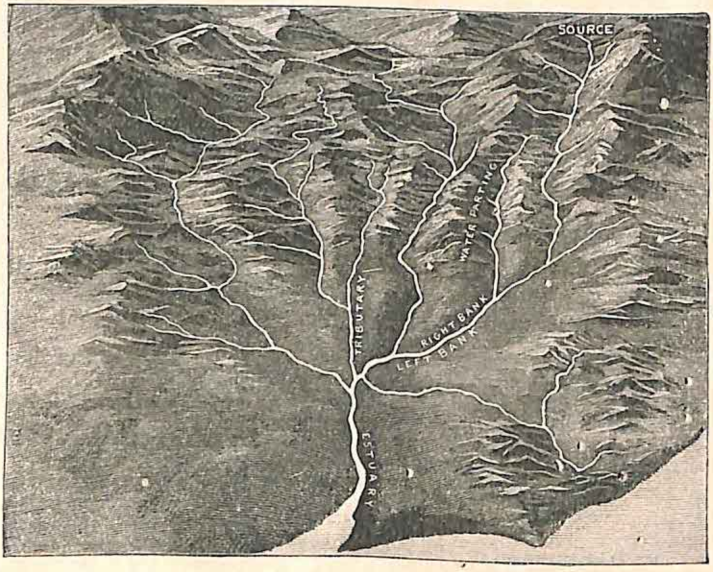


FIG. 159.—The basin of the river Ouse.

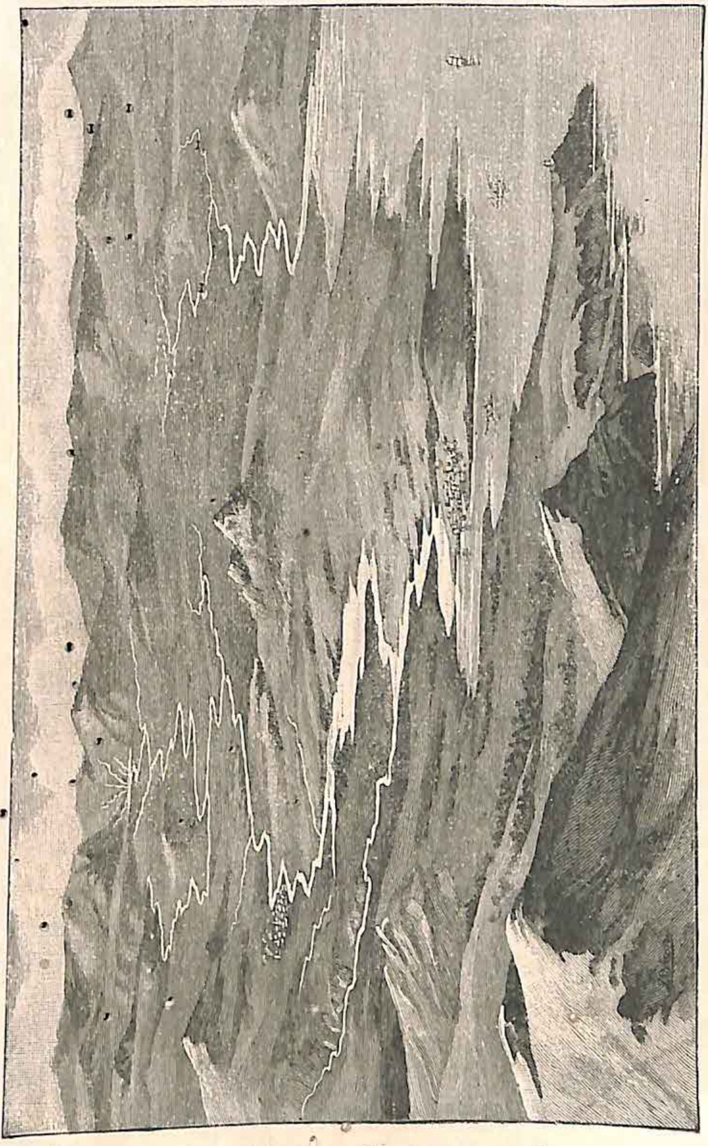


FIG. 160.—The course of a river from its source to the sea.

CLASSROOM WORK.—The part of the stream visited should be pointed out on an ordnance survey map; a clay model should be made, or a large map of the district drawn on the B.B. (figs. 159, 161).

The facts observed should now be accounted for in a manner somewhat as follows:—

| FACTS OBSERVED | EXPLANATIONS OF THOSE FACTS |
|---|---|
| 1. Water in stream flows. | Pour water in trough; note its stillness. Tilt trough; note water flows. Compare tilted trough to bed of stream, and deduce that water flows downwards because it is trying to get as low as possible. |
| 2. Stream flows faster in middle than at sides. | Pour sand down tilted trough. Show that some sand is prevented from falling by sides of trough. Compare friction of sides of trough with friction of sides of stream. |
| 3. Stream has a winding course. | On a tilted board covered with sand place a few pieces of clay. Carefully pour water from upper end and note winding of stream of water. |
| 4. Stones are found in rapidly moving parts; gravel is found in more slowly moving portions; whereas sand is found in comparatively still spots. | Have sand, small and large stones in a pail of water, or, better still, in a glass vessel. Stir rather gently, note that sand is carried round by water, but that stones are unaffected. More vigorous stirring brings the stones into a state of suspension—first the small ones and afterwards the large ones. Suddenly stop stirring, and note that the large stones are dropped first, then the smaller ones, and last of all the sand. |

### B.B. SKETCH.

**The stream flows because water tries to reach its lowest level.**
**The stream flows faster in middle than at sides because the water flows slower through rubbing against the sides or banks**
**The stream winds because it is easier for the water to make a bed in soft than hard rock.**
**Quickly moving water can carry stones.**
**Water nearly or quite still cannot carry even sand**

## A RIVER (SECOND LESSON).

| FACTS OBSERVED | EXPLANATIONS OF THOSE FACTS |
|---|---|
| 1. The pebbles brought away should be examined and classified somewhat as follows:—<br>(*a*) Stones more or less angular.<br>(*b*) Stones rounded on one side, flat on other.<br>(*c*) Stones rounded on all sides. | By comparison with rocks around, deduce that some of the stones at least must have once formed part of the neighbouring rocks; further, that those marked (*a*) have been recently detached from rocks, those marked (*b*) have probably rested some time in bed of stream, whilst the stones marked (*c*) have probably been transported for a long time by the stream. |

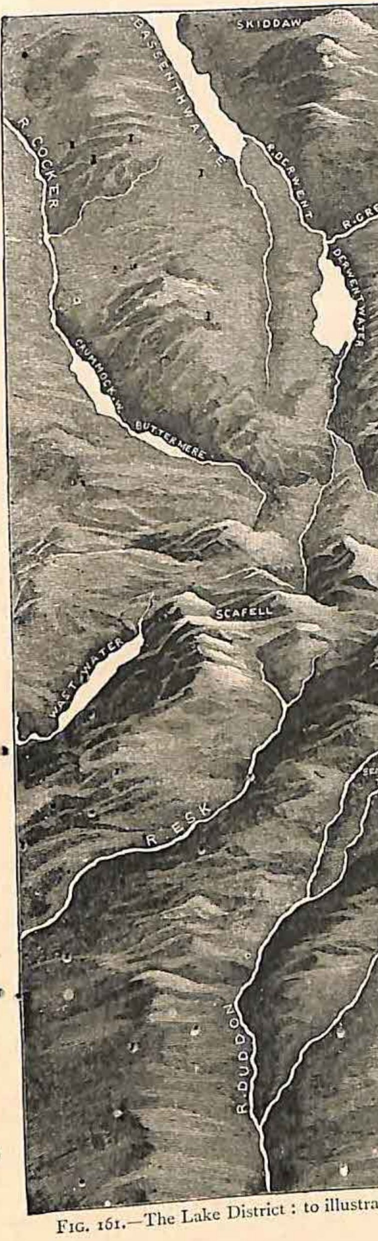
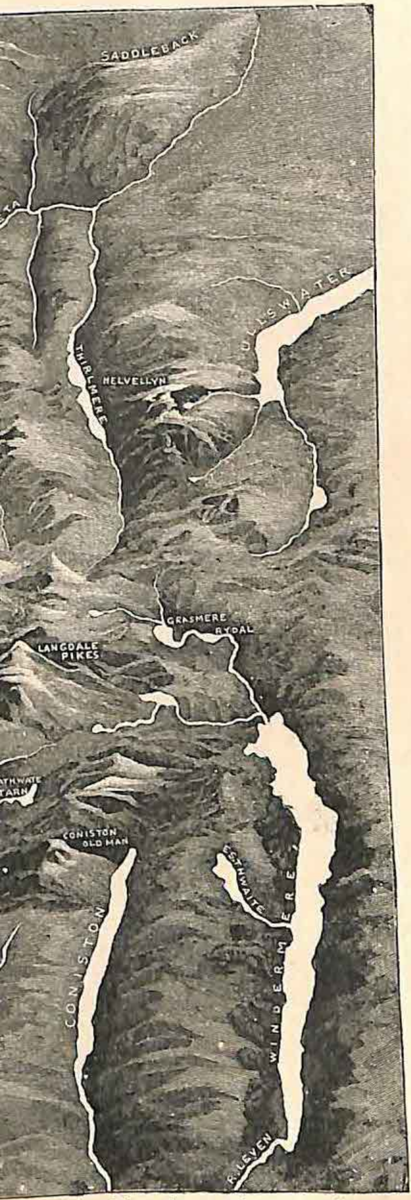


Fig. 161.—The Lake District : to illustra



te mountains, lakes, rivers, and water-partings

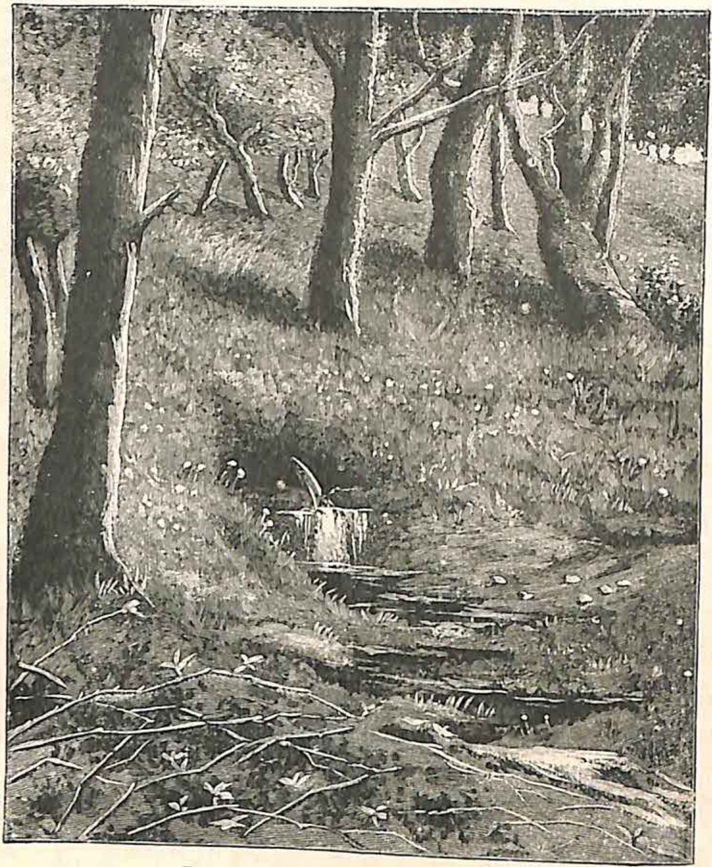


FIG. 162.—A spring issuing from a hillside.

| FACTS OBSERVED | EXPLANATIONS OF THOSE FACTS |
|---|---|
| 2. (*a*) The bottles should be allowed to stand, and the fine sediment deposited should be noticed. | The water carries along matter which is dissolved in it (*i.e.* in solution), and matter not dissolved in it (*i.e.* in suspension). |
| (*b*) A portion of the clear water above should be evaporated and the residue shown. | |

| FACTS OBSERVED | EXPLANATIONS OF THOSE FACTS |
|---|---|
| 3. The deposition of sand at confluence of water-course with stream. | The quickly moving water of the water-course meeting with the more slowly moving stream becomes slowed down, is consequently not able to carry so much matter, and drops some, forming a little bank or island. Extend this knowledge to the formation of *deltas* (fig. 163).<br>[*Note that the term delta is applied to the land brought down by the river, not to the river itself.*] |

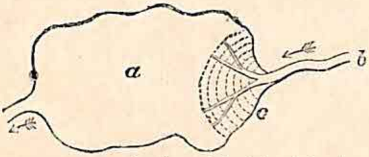


FIG. 163.—Stream (*b*) running into a lake (*a*) and forming a delta (*c*).

4. Technical terms connected with a river, such as *source* (fig. 162), *bed*, *water-shed*, *basin*, &c., can now be taught. Pictures, diagrams, &c., should be freely employed.

## HOW TO PREVENT PARAFFIN LAMP ACCIDENTS.

**Things required.**—*A lamp which fulfils all the conditions set out in Note A below; several lamps of faulty construction; paraffin, evaporating dish, spirit-lamp, matches.*

1. Revise lesson on *Paraffin* (Standard II., p. 80), drawing especial attention to the following points:—
   (*a*) Paraffin when quite cold extinguishes a light the same as water does.
   (*b*) Paraffin when slightly warmed gives off a gas which ignites easily.
   (*c*) Paraffin gas when mixed with air explodes in the same way as coal gas when mixed with air explodes. (Coal Gas, Standard II., p. 89.)

2. Hence, argue **it is dangerous**:—
   (*a*) **To allow paraffin oil to get warm.**
   (*b*) **To allow paraffin gas to mix with air.**

3. Show lamp with a glass reservoir and small base. Show how easily the lamp can be upset, the danger of the glass reservoir breaking, of the oil running out, and if the lamp is alight, of the oil taking fire. Argue that **a good lamp should have**:—
   (*a*) **A broad heavy base to prevent upsetting.**
   (*b*) **A metal reservoir to prevent breakage if the lamp is upset.**
   (*c*) **No opening in reservoir through which oil can flow should lamp be upset.**

4. Infer danger of filling lamp with oil before a fire or while the lamp is burning. The oil when heated gives off a gas which, mixing with the air, forms an explosive compound.

5. Show lighted lamp, ask for suggestions as to the best way of extinguishing it. Infer danger of turning lamp down too low or of blowing *down* the lamp glass, as either method tends to force the flame into the gas above the oil in the reservoir. Demonstrate the best way of putting lamp out as detailed in B.B. Sketch.

## B.B. SKETCH.

**A paraffin lamp should have :—**

**1. A metal reservoir**
**2. A broad heavy base**

**A lamp should never be filled near a light**

**To extinguish a lamp we should turn the wick down a little and blow sharply across the top of the chimney.**

*Note A.*—The following suggestions, issued by the London County Council, relating to the *Safe Construction and Proper Management of Paraffin Lamps*, may be of interest to the teacher, who might think proper to introduce into the lesson some more precautions than those already dealt with :—

### CONSTRUCTION.

1. The oil reservoir should be of strong metal, properly folded and soldered at the joint, and should not be of china, glass, or other fragile material.

2. There should be no opening between the reservoir and the burner, other than through the tube which holds the wick; and this tube should be extended to within ¼ inch of the bottom of the reservoir, and should have no opening into the reservoir except at its base.

3. The burner should be securely attached to the reservoir, preferably by means of a strong and well-made screw attachment.

4. There should be no openings through which oil could flow from the reservoir should the lamp be upset.

5. Every table lamp should have a broad and heavy base, to which the reservoir should be strongly attached.

### WICKS.

6. Wicks should be soft, and not tightly plaited, and should quite fill the wick-tube without having to be squeezed into it.

7. Wicks should be frequently renewed, and before being put into lamps should be dried at a fire and then immediately soaked with oil.

### MANAGEMENT.

8. The reservoir should be filled with oil before the lamp is lit.

9. The lamp should be kept thoroughly clean, all oil should be carefully wiped off, and all charred wick and dirt removed before lighting.

10. When first lit the wick should be partially turned down, and then gradually raised.

11. The wick should not be left turned down, as there is then a greater liability to explosion in lamps of unsafe construction.

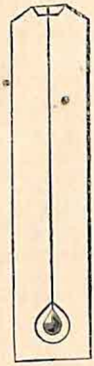
12. Lamps which have no extinguishing apparatus should be put out as follows: The wick should be turned down until there is only a small flickering flame, and a sharp puff of breath should then be sent across the top of the chimney, but not down it.

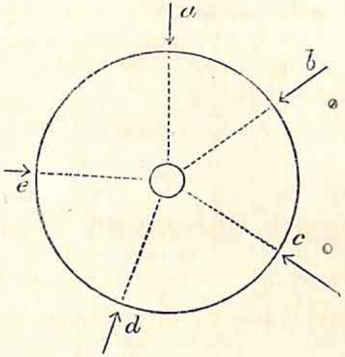
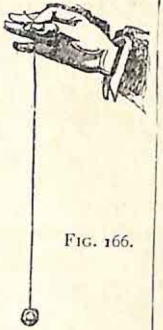
13. Cans or bottles used for oil should be free from water and dirt, and should be kept thoroughly closed.

*Note.*—These suggestions apply to ordinary petroleum or paraffin lamps such as are generally used, and not to benzoline or spirit lamps.

## PLUMB LINE.

**Things required.**—*A number of reading books; piece of lead attached to string; plumb line mounted on wood; piece of iron, wood, feathers, cotton, sheet of paper, school globe, pin, spirit-lamp.*

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 1. (*a*) Pile a dozen books on top of one another so that the pile leans somewhat in one direction.<br>(*b*) Pile another dozen books in a strictly vertical column. Let child see which is the easier to push over.<br>(*c*) Compare the two piles to walls, houses, &c. | The second pile requires more strength to push it over than the first pile. | **Walls, houses, &c., are much stronger if built quite upright than if they are built slanting.** |
| 2. The question will now arise, How is the bricklayer to know that he is building the wall quite upright? Introduce plumb line; point out its parts. Show how the bricklayer uses it. Test various objects in room to see if they are vertical or not. |  FIG. 164. | **The bricklayer uses a plumb line to help him to make walls, &c., upright.** |
| 3. (*a*) Hold piece of iron and wood in hand; let go.<br>(*b*) Hold sheet of paper out flat; let it go. | The iron and wood fall to the ground.<br>It falls slowly towards the earth. | **All bodies, unless they are prevented, fall to the earth.**<br>**Sometimes we prevent bodies from falling to the earth by holding them.** |
| (*c*) Roll up sheet of paper into a ball; let it go.<br>(*d*) Hold a few feathers in hand; let go. | It falls more quickly towards the earth.<br>They do not fall at once to the ground, but float some time in the air. | **Sometimes the air holds things up and prevents their falling to the earth.** |
| (*e*) Tie several feathers into a bundle; let go. | The bundle of feathers falls to the ground. | |

| OBSERVATIONS AND EXPERIMENTS | RESULTS | INFERENCES |
|---|---|---|
| 4. Introduce school globe, stick pins in various parts of globe to represent men; ask in what direction things dropped by these men would go. Draw fig. 165 on B.B. |  FIG. 165.—O is the centre of the earth. The arrows *a*, *b*, *c*, *d*, *e*, represent the directions in which things would fall at different parts of the earth's surface. | **All bodies fall, or try to fall, towards the centre of the earth.** |
| 5. (*a*) Place piece of string on table; note that it is not straight.<br>(*b*) Let two children pull ends of string.<br>(*c*) Suspend lead attached to string; note string.<br> FIG. 166. | The string becomes straight.<br>The string is straight. | **A piece of crooked string can be made straight by pulling it.**<br>**The ball, in trying to fall to the centre of the earth, pulls the string straight.** |
| 6. (*a*) Suspend plumb line from a support (for example, a gas bracket) at a measured distance (say three feet) from the wall. Burn string with spirit-lamp. Note distance from wall of spot on floor on which lead falls.<br>(*b*) Refer again to straightness of string in plumb line. | The lead strikes the ground three feet away from the wall. | **Things in falling towards the centre of the earth, fall in a perfectly straight line.**<br>**The direction of the string of the plumb line is a perfectly upright line.** |

B.B. SKETCH.

**Plumb line.**

**Used by bricklayer as a help in building walls upright**

**All bodies fall, or try to fall, towards the centre of the earth.**

**The plumb line points to the centre of the earth in a perfectly upright line**

*Note.*—The definitions of the terms vertical, horizontal, perpendicular, might now be taught.

## INSECTS AND FLOWERS (FIRST LESSON).

**Things required.**—*Specimens of all the flowers mentioned in the lesson.*

OUTDOOR WORK.—Visits should be paid to fields (for wild flowers), to gardens, and to a greenhouse. Ask the children to note:

1. The general appearance of the flowers mentioned in the lesson.
2. The positions and localities in which they grow.
3. The insects on the flowers :—
    - (*a*) On irregular flowers.
    - (*b*) On bright coloured flowers.
    - (*c*) On scented flowers.
4. The blossom of the willow or juniper (May or June). Male catkins on one plant, and female on another plant.

CLASSROOM WORK.

1. Show a specimen of any flower with well-marked *anthers* and *stigma*. To fertilise a plant the pollen dust from the anthers must come in contact with the stigma. This is done in one of three ways :—
    - (*a*) **By the wind**—in many cases.
    - (*b*) **By insects**—in most cases.
    - (*c*) **By self-fertilisation**—in some cases.

    We are concerned only with the second case in this lesson, that of insects.
2. Show different specimens of flowers (*the choice will depend upon local circumstances and the time of the year*) and point out the honey glands.
    - (*a*) In certain *pæonies*—in the sepals.
    - (*b*) In the *buttercup*—in the petals.
    - (*c*) In the *pulsatilla*—in the stamens.
    - (*d*) In *caltha*—in the ovary.

    Insects visit flowers for their honey or their pollen ; hence they must be able to get at the honey glands.
3. Show the necessity for the visits of insects.
    - (*a*) Show a young specimen, and an older specimen of the same flower, of any suitable member of the *cruciferæ*.
        1. In the young specimen note that the anthers have the side which opens to let out the pollen turned towards the pistil.
        2. In the older specimen, before the anthers have finished growing, they twist themselves round and turn the other side to the pistil ; **hence they cannot fertilise themselves.**

(*b*) Show some pendent flower where the pistil hangs below the anthers.
  1. The stigma is on the lower surface.
  2. Hence no pollen can fall on it.

**Therefore these flowers cannot fertilise themselves.**

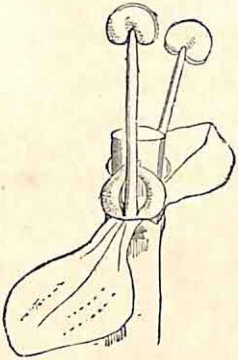


FIG. 167.—Male flower of water star-wort (greatly magnified), with two sickle-shaped bracts.

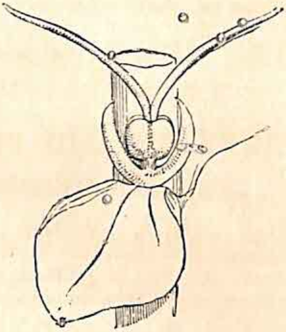


FIG. 168.—Female flower of water star wort (greatly magnified).

(*c*) Show, or draw, a water star-wort.
  1. The stamens are on one flower.
  2. The pistil is on another.

**Therefore such flowers as these cannot fertilise themselves.**

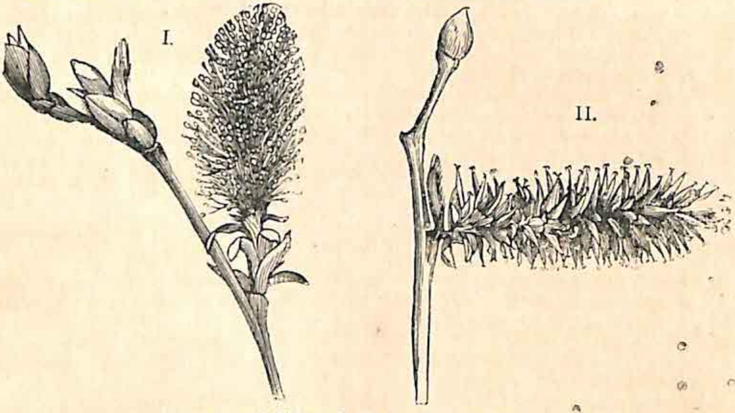


FIG. 169.—Sallow. I. Male catkin. II. Female catkin.

(*d*) Examine the flowers of the willow, juniper, or poplar.
  1. The flowers are catkins.
  2. The male catkins are on one plant.
  3. The female catkins are on another plant.

**Obviously such plants cannot fertilise themselves.**

(*e*) Show specimens of the sage or arum; one specimen with ripe pistils, and one with ripe anthers.

1. The stamens and pistil are both on one flower.
2. They are not ripe at the same time.

**These flowers cannot fertilise themselves.**

**Hence the visits of insects are necessary to these flowers.**

Drawing and composition to follow as usual.

## INSECTS AND FLOWERS (SECOND LESSON).

### UNWELCOME INSECTS.

**Things required.**—*Specimens of some of the following plants, e.g. the common teasel, cyclamen or snowdrop, snapdragon, campanula, white dead nettle, narcissus or primula, verbena or gentian, gooseberry flower, polygonum amphibium, lettuce leaves; a few ants.*

OUTDOOR WORK.—As in the last lesson. In addition, note:

1. The *kind* of insects on the flowers—bees, wasps, flies, &c.
2. Few or no *ants.*
3. The position and appearance of each flower used in this lesson.

CLASSROOM WORK.—Why few or no ants? They are very fond of honey.

1. The ant is a creeping insect.
2. Such insects would naturally pass from one flower to another on the same plant.
3. It is generally best that **the pollen should be brought from a different plant.**
4. Ants would also creep from one flower to the next, which might probably be a different species, and so the pollen would be wasted. **The pollen must come from the same kind of flower.**
5. Touch an ant with a bit of grass or thread. It will most probably seize the grass in its jaws. Then, if the delicate tip of the trunk of a bee, butterfly, &c., should touch an ant on the flower it would probably find it seized by the strong and horny jaws of the ant, and as a consequence would probably never visit the flower again. **This would mean death to the plant, for it is fertilised by insects.**

*From this we infer many plants do not want ants.* How do they keep them away? Teach the answer by the aid of some of the following specimens.

1. Show a common teasel. Note its *cup formed by little leaves.* This cup nearly always contains water. *The ant would have to go through this water to get at the honey.*
2. Show a specimen of the cyclamen or snowdrop. Note the leaves with *curved and slippery surfaces*, forming a collar round the stem. *The ants cannot get over these surfaces.*
3. Show a snapdragon. The *parts of the flower are crowded together, and only a somewhat powerful insect could force its way in.* None but the humble bee can do this.
4. Show a campanula, and note :—
   (*a*) The stamens are swollen at the base.
   (*b*) They are in close contact with one another.
   (*c*) Consequently they form, as it were, *the lid of a hollow box in which the honey is hidden.*

5. Show a white dead nettle, and note :—
   (*a*) The flowers form a narrow tube.
   (*b*) This is protected by hairs.
6. Show a narcissus or primula. Note that *the tube is so narrow that not even an ant could get down it.*
7. Show a verbena or gentian, and note :—
   (*a*) The hairs on the flowers.
   (*b*) The hairs have a tendency to point downwards, which *makes them more effective for keeping out the ants.*
8. Show the flower of the gooseberry. The flower is sticky. Small insects would be caught in this *sticky substance.*
9. Show a specimen of polygonum amphibium—a land specimen. Note that the plant is covered with a multitude of glandular *sticky hairs.*
10. Get some lettuce leaves. Place some ants on them. The ants cut through the delicate skin of the leaf, a milky juice comes out, and *the ants become glued down.* (Kerner's Experiment.)

**From all these cases we learn that the structure of plants is altered to protect them from unwelcome insects.**

Composition to follow.

## INSECTS AND FLOWERS (THIRD LESSON).

### WELCOME INSECTS. COLOUR AND INSECTS.

**Things required.**—*Specimens of all the flowers required for Classroom Work.*

OUTDOOR WORK.—As in the two previous lessons. In addition note :—

1. The red and white campions. The red are fragrant ; the white give out no fragrance. A visit to the same flowers in the evening would find the white fragrant and the red not. Note also that probably there will be bees on the red, but none on the white. An evening visit would probably find the white visited by **moths** and the red deserted. The white campion, then, is a night flower, and **most night flowers are pale.**
2. The brownish flowers, like the scrophulariaceæ, hellebore, &c. If insects are present they most probably will be **wasps.**
3. Any livid or flesh-coloured flowers will be visited by **flies.**
4. The common lime tree. The blossom is abundant and fragrant. On a suitable day note the number of bees on it.
5. Variegated flowers are visited by minute insects. Examine specimens of the common arum. Probably a large number of flies will be found in it.
6. The purple lines on the petals of the geranium palustre. Lines and bands on any other flower will do as well.

CLASSROOM WORK.—Recapitulate the observations made during the outdoor work, and note :—

1. *Night flowers* **are generally pale, fragrant in the** *evening*, **and are visited by moths.**
2. **Flowers visited by insects during the day are sweet-scented or bright-coloured.**
3. **Different insects like different flowers.**
4. **Minute insects go to variegated flowers.**

Take any flower (geranium palustre). Show the purple lines. Trace them to the honey glands. Deal with other specimens in the same way, and so lead the class to infer that **all such marks are honey guides.**

## INTERESTING CASES OF INSECT-FERTILISATION.

**Things required.**—*Specimens of sage and arum for individual examination.*

1. Distribute specimens of the *sage* flower. Note that :—

(1) The corolla is two-lipped.

(2) The lower lip forms a convenient *resting-place* for the insect to stand upon.

(3) The upper lip protects the stamens and pistil from rain. Sketch each step on the B.B. as it is pointed out.

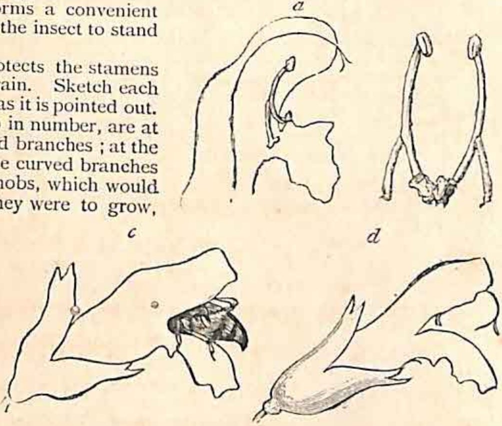


FIG. 170.—Sage fertilisation.

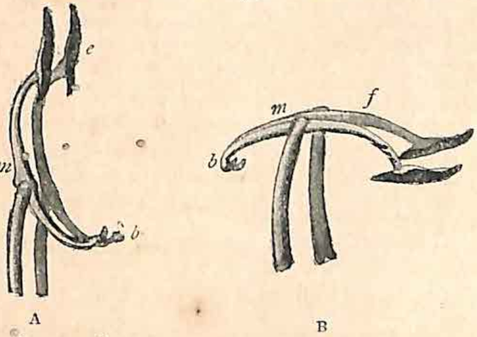


FIG. 171.—Stamens of sage. A, in natural position ; B, when moved by a bee.

(4) 'The stamens, two in number, are at the end of curved branches ; at the lower end of the curved branches are two little knobs, which would be stamens if they were to grow, and these knobs are united together (*b*), so that if either be pushed it affects both stamens. The stamens are full of pollen and are placed upon the movable curved branch (*m*) in such a manner that if the knobs are pushed backwards and upwards the stamens come downwards and forwards (*e* and *f*). In the corolla tube honey is secreted. The style and stigmas at first are placed well back against the upper lip, and are not fully grown until after the pollen. When they are fully grown, however, the style bends forward (*d*), bringing the stigmas near the centre of the mouth. If a bee visits one of the flowers which has its pollen fully grown in order to seek for honey, it will, on entering the

flower and plunging its trunk into the tube, *strike its head against the knobs, bringing the anthers down against its sides, covering its body with pollen* (*c*). If it now visits another flower *in the same condition* it will simply have its stock of pollen increased; but if it visits a flower *which has its pistil bent over* evidently the stigmas will strike against the insect's back and some of the pollen scattered there will cling to the sticky surface of the stigma' (*Edmond's Botany*), and so the flower will be fertilised.

2. Distribute specimens of the common arum (the *cuckoo pint*, or *lords and ladies* of the village children). Note :—

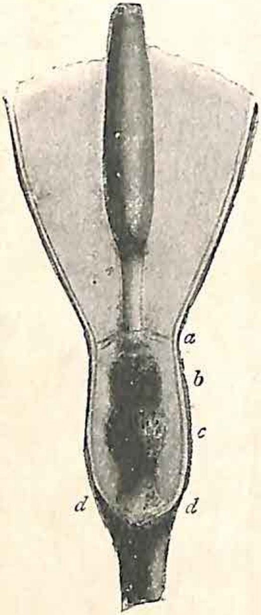


FIG. 172.—Section of arum.

(1) Its large green leaf.

(2) The central pillar. It is club-shaped.

(3) The fringe of hairs (*a*). They turn downwards.

(4) The anthers (*b*).

(5) The stigmas (*c*).

(6) The cup-like bottom of the tube (*d*).

It looks as though the anthers could easily drop their pollen on to the stigmas, and so the flower could be easily self-fertilised. But *the stigmas ripen before the anthers*, and by the time the anthers have shed their pollen the stigmas are incapable of fertilisation; **hence the flower cannot fertilise itself.** Nor can the pollen be carried away by the wind, for it drops to the bottom of the tube.

Now, from the Outdoor Work it is known that the arum is visited by myriads of small flies. They enter the cup (*d*) after the honey. The hairs (*a*) let them in, *but will not let them out*; hence they are imprisoned. By and by the ripe time of the stigmas is over and each secretes a drop of honey. The insects now get the honey they came for. The stigmas having ripened, the hairs gradually shrivel up, their work of protecting the anthers and stigmas being no longer necessary. And so the insects can now quit the flower with the pollen sprinkled on their backs to carry it to some other arum, where they probably rub some of it against the stigmas and so fertilise the flowers. Hence we see:

1. **That flowers are necessary to insects.**
2. **That insects are necessary to flowers.**

Drawing and composition to follow.

## FLOWERS OF A CURIOUS SHAPE.

**Things required.**—*Specimen flowers of the orchids and the foxglove; some fruit like an apple to illustrate a persistent calyx; a root of monkshood and another of horseradish.*

OUTDOOR WORK.—This lesson could probably be given best in *July* or *June*.

1. Take the children to see the *orchis* growing in its natural surroundings, and note :—

   (*a*) The leaves are dark and glossy, and spotted in some kinds; they are long and often as broad at the base as elsewhere; they are sheathed a the base and parallel veined.

(*b*) The flowers are solitary, growing up the stem in spikes, the flowers having no stalks, or they have stalks and grow like the flowers of the snapdragon or the currant.

(*c*) The nature of the soil (moist, dry, chalky, &c.) in which they grow, and whether sheltered or exposed.

(*d*) If the species be the *purple orchis* note its probable neighbours—hyacinths or cowslips.

2. The foxglove is one of the handsomest of British wild flowers.
   (*a*) A tall plant, two to four feet; sometimes even six feet in gardens.
   (*b*) The lower leaves are crowded, and have stalks; the upper ones are alternate. The leaves are very large, six to twelve inches.
   (*c*) Its *flowers* are purple, orange-yellow, or white; they are drooping and bell-shaped.

CLASSROOM WORK.—Specimens of each kind to be distributed for examination. These specimens should have been gathered during the outdoor visits. *The children should also be invited to bring their own specimens.*

## THE ORCHID.

Class to note:—

1. Sepals and petals the same colour.
2. There are three of each, and each petal comes between two sepals.
3. The lower petal is much the largest.

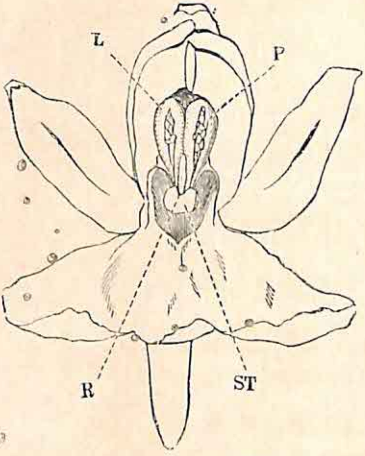


FIG. 173.—Flower of an orchid looked at in front, the ovary being concealed; L, P, anther lobes, each containing a pollen-ball; ST, stigma; R, rostellum (magnified).

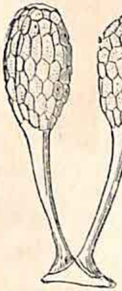


FIG. 174.—Pollen-balls of an orchid (greatly magnified).

4. The corolla has a long, hollow spur standing out at the back of the flower.
5. Only one stamen, with its two halves separated from each other. Note that they lie at the back of the flower, with a petal overhanging them. Note the pollen ball with its long stalk and *sticky tip*. Put a strong lens over them. They are covered with a thin skin, to keep the air from them. *If the air got*

*to them it would dry the sticky fluid and then the pollen balls could not be removed easily by the insects.*

6. The pistil of a flower usually consists of stigma, style, and ovary, but here there is no style. The stigma is at the top of the hollow spur, and *just beneath the pollen balls.* The ovary is very peculiar, being green and twisted, and looking like the stalk of the flower. Cut it across, there are three rows of small ovules.
7. 'Take a flower which has but recently expanded, and push a sharp pencil gently into the spur. It is found that on touching the sticky gland (rostellum) its pouch-like membrane is pushed down, and the pencil comes in contact with the sticky substance at the base of the pollen ball. On removing the pencil one or both of the pollen balls are removed attached to it. It will be found after removal they gradually bend over towards the point of the pencil. If an insect, such as a bee, visits the plant for the honey contained in the spur, it presses its head against the sticky gland and flies away with the two pollen balls attached; on visiting a second flower these pollen balls have bent forward, so that instead of returning to the same place from which they were taken in the previous flower, they strike against the sticky stigma, and some of the pollen remains attached' (*Edmond's Botany*).

## THE FOXGLOVE.

Note :—

1. The *calyx* is irregular, consisting of five united sepals, and is persistent. Illustrate with an apple for 'persistent.'

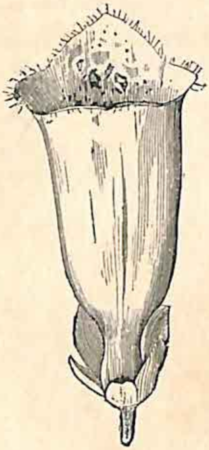


Fig. 175.—Flower of fox-glove.

2. The *corolla* is all in one piece. It forms a kind of bell which droops as soon as it opens. **This protects the stamens from rain and dew and wind.**
3. Tell the origin of the name. The bell-like corolla is supposed to be shaped something like the finger of a glove. *Fox* is a corruption of *folks*, which was another name for *fairies* in olden times. Hence name means fairies' glove.
4. The *stamens* are ascending and peculiar. There are four of them, two being on long and two on short stalks. At first the *anthers* are horizontal (A); then the upper anthers ripen and become upright (B); later on all the anthers ripen and all become upright (C), so that they can shed their pollen profitably.

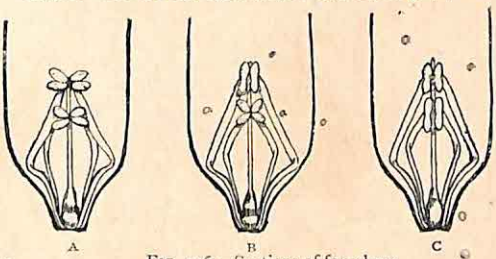


Fig. 176.—Sections of fox-glove.

5. The *stigma* has two lobes, and rises between the stamens. The flower is fertilised by humble bees, because *they alone among insects are large enough to fill the bell, and thus to deposit pollen on the stigma.*

Drawing and composition to follow.

# FOREST TREES: THE OAK.

**Things required.**—*Specimen flowers, leaves, wood, oak-apples, acorns, oak branches with leaves; also branches of beech, birch, and Spanish chestnut with leaves; plum or cherry.*

OUTDOOR WORK.—Visits at different seasons should be paid to the oak. From the observation of the tree, note :—

1. Its size and grand appearance. Compare it with the neighbouring trees; it is the monarch of the forest.
2. Its rough bark, and its big, gnarled (*explain*) branches spread out like arms.
3. The *two kinds of flowers*—male and female. Note their form—called catkins. Male catkins are from one to three inches long, and they appear with the leaves. Note that the flowers hang downwards, that they are small, and in clusters (April, May).
4. The strange shaped *leaves* with curved edges; the abundance of leaves in a young oak.
5. A winter visit will show the tree to be bare of leaves; the leaves are not evergreens, but fall off each year.
6. Note other plants growing on the tree: mosses, lichens, fungi, mistletoe, as the case may be. Ivy grows on some.
7. In the proper season note the *fruit* (acorns); some have stalks and some have not.
8. Note the galls on the dead branches and flower stalks; note also the oak-apples.
9. Call attention to the *leaf arrangement*. **It gives the leaves the greatest amount of light and air.**

CLASSROOM WORK.

## FLOWERS.

Distribute flowers (April or May) and let class note their general appearance so as to aid in their future recognition.

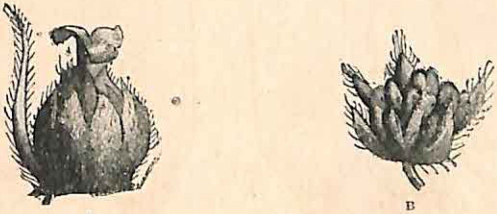


FIG. 177.—Oak. A female flower; B male flower.

## LEAVES.

Distribute leaves for examination, and note :

1. Their *size*, from three to six inches; their narrow base; their in-and-out edge.
2. Show the underside of the leaves, and note the oak spangles. They are caused by gall flies.
3. Examine some small branches or shoots with leaves, and note that **the size of the leaf has some relation to the thickness of the stem.**

4. Note also that **the width of the leaf bears some relation to the distance between the internodes.** To illustrate 3 and 4, compare shoots or sprays of the oak, beech, birch, and Spanish chestnut. These facts can then be deduced from an examination of the specimens.

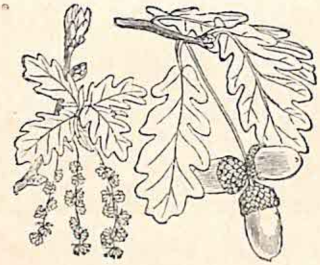


FIG. 178.—The common oak.

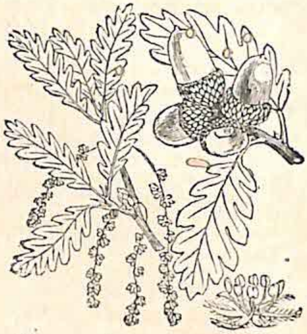


FIG. 179.—The sessile-fruited oak.

## WOOD.

Show specimens of the wood. Let them handle it; it is hard, strong, and lasts a long time; hence used for making ships, pulpits, picture frames, furniture, seats in churches, and things generally which require to be strong and last a long time.

## FRUIT.

1. Show some oak-apples; *not* the proper fruit of the tree. Compare them with acorns. The oak-apples are caused through the boring of insects, which lay their eggs in the holes thus bored.

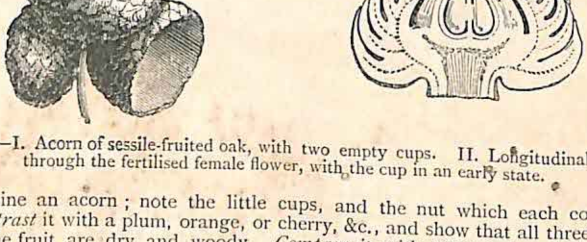


FIG. 180.—I. Acorn of sessile-fruited oak, with two empty cups. II. Longitudinal section through the fertilised female flower, with the cup in an early state.

2. Examine an acorn; note the little cups, and the nut which each contains. *Contrast* it with a plum, orange, or cherry, &c., and show that all three layers of the fruit are dry and woody. *Compare* it with some nut, and show the similarity of structure.

Drawing and composition to follow.

# FOREST TREES: THE BEECH.

**Things required.**—*Specimen flowers, leaves, wood, fruit; knobs from the beech tree; sprays of beech, birch, oak, Spanish chestnut.*

OUTDOOR WORK.—The tree should be visited at different seasons and the following facts noted:—

1. The *noble look* of the tree. It is one of the most graceful and noble of our trees. Very stately, and rivals the oak in its size and outline.
2. Its smooth, clean bark. In an old beech the bark will be *olive grey*, and patched and dotted with *various tinted lichens* and *dark green velvet moss*.
3. The soil in which the beech is growing. Most probably it will be a light soil.
4. The strange form of its trunk, with all sorts of hollows and knobs. Note that *the knobs vary in size*, from a pea to a cricket ball. **They are leaf buds which have gone to sleep.**
5. The flowers (April or May) with their yellow anthers. They hang down in long heads. Some flowers are on shorter stalks than others; these are the female flowers.
6. The pretty, light green, round leaves. In *autumn* they are a deep orange yellow. The *purple beech* has its leaves a *cherry-red colour* when young. At midsummer they become *dark purple*.
7. In October or November note the fruit: the *beech-mast*. It is bristly and has two sharp cornered triangular nuts.
8. The fungi of the beech woods (*truffle, morel*, &c.).

CLASSROOM WORK.

## FLOWERS.

Distribute flowers for examination, and let the class note their general appearance so as to aid in their future recognition. Note the ovary.

## LEAVES.

Distribute leaves for examination.

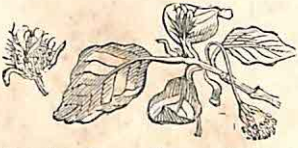


FIG. 181.—Leaves, flower and fruit of the beech.

1. Note the hairs on their edges.
2. Their light green colour and round shape.
3. They have *stipules*; hence the leaf is perfect.
4. Specimens of the leaf of the purple beech should also be shown.
5. In the ordinary beech note the gentle swell at the base of the leaves. This causes the leaves so to fit each other that **no space for air and light is wasted**, and there is no overlapping.
6. See 'Leaves' 3 and 4, Lesson on Oak. In addition, to illustrate the statement that the distance between the internodes bears some relation to the width of the leaf, place a spray of beech over one of Spanish chestnut.

## WOOD.

1. Let the children see and handle specimens of wood. It is hard and brittle but does not last long unless kept under water. It is soon destroyed by insects. Used for *bowls, bedposts, toys, land boxes, hat cases, mills, weirs, sluices, butchers' trays.* It makes good fuel. The teacher should try to show the suitability of the wood for these purposes.

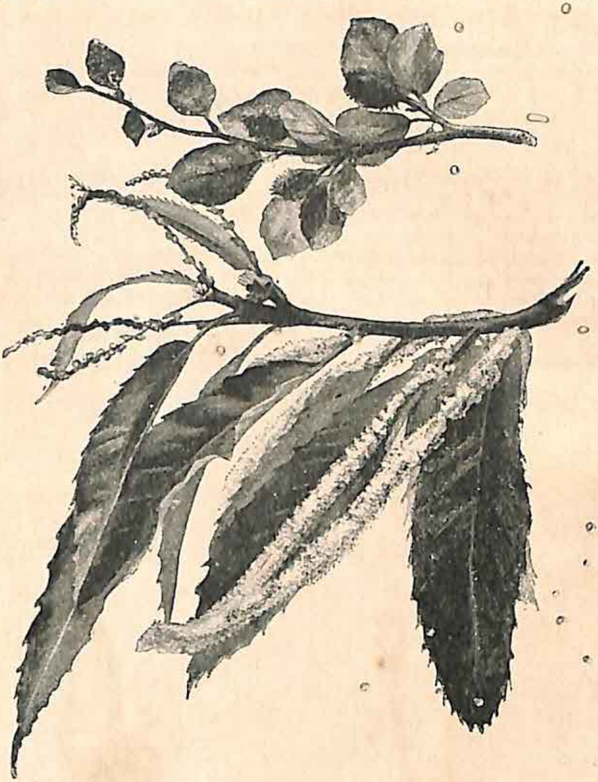


FIG. 182.—Beech and Spanish chestnut.

2. Show some knobs (*dormant buds*) which have been pulled off the tree. They are marked with rings like other branches. A fresh ring is added every year.

## FRUIT

Show some beech-mast. When fresh they have a sweet taste, like walnut. Pigs are fed on them.

Drawing and composition to follow.

## RIVERSIDE TREES: THE WILLOW.

**Things required.**—*Specimens of flowers, male and female; leaves and wood of both the white willow and the goat willow.*

OUTDOOR WORK.—The tree should be visited at different seasons.

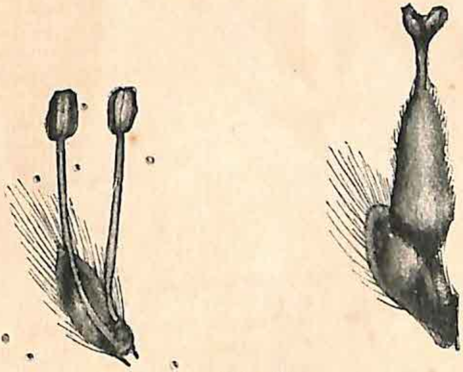
1. Note position by riverside.
2. Note the common white willow: its fine look; its pretty form.
3. Contrast it with the goat willow (the *round-leaved sallow*), which is only a moderately sized tree and generally kept down to underwood or hedgeplant size. This is done for the sake of the young shoots, which are used for *wickerwork* and *hurdle-making*.
4. Note the *feathery-looking leaves* of the *white willow*; its *silvery* tint when ruffled by the breeze. Note the effect of the contrast with the neighbouring trees of a deeper shade. The leaves of the *sallow* will be seen to be larger and broader.
5. Visit a *sallow plantation* when the periodical fall of underwood is going on, and note (probably) a number of newly cut stumps with holes about the size of one's little finger, and extending downwards through the axis of the stem. These are the work of the larva of a *moth*.

CLASSROOM WORK.

### FLOWERS.

Distribute flowers (May) for examination, and note :—

1. The flowers are catkins.
2. The catkins differ in appearance. Some are male and some female.



Flowers of the willow.

FIG. 183.—Male flower. FIG. 184.—Female flower.

3. The male flowers are on one plant; the female on another.
4. The catkins are called 'palms.' Note their sweet scent (for insects).

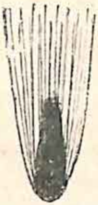


FIG. 185. —Seed of willow.

5. Examine the female flowers, which produce the well-known cotton-tufted seeds which fly about.
6. Note the male flowers.
7. Note how conspicuous the yellow or silky white clusters are. **The bright colours are to attract insects.**

## LEAVES.

Distribute some leaves of both the *white willow* and the *goat willow.*

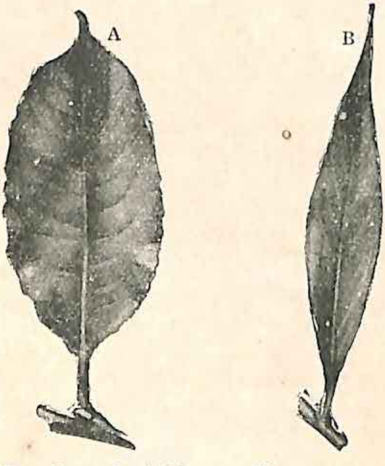


FIG. 186. —A, Leaf of the goat willow ; B, leaf of the white willow.

1. Note that the leaves of the *white willow* are lance-shaped, narrow, sharp-pointed, with *glands* on the lowest dents in the edges of the leaf, *silky on both sides* (except old leaves), and *white underneath.* **This gives the foliage its silvery appearance.** The size of the leaf is from 2 to 4 inches, and it has *stipules—i.e.* the leaf is perfect.
2. Note that the leaves of the *goat willow* are wrinkled, waved, *pale and downy beneath and dark green above.* Its stipules are different in shape to those of the white willow, and its leaves are larger and rounder.
3. Show leaves of the *white willow* with *red fleshy marks.* These are *galls* produced by a small kind of *sawfly*, the grub of which may be found in the gall.

## WOOD.

Show specimens of the wood. It is elastic, tough, durable, and not liable to split from sudden shock. Hence used for lining stone carts and barrows, for boat-building and small ships, mill work, turnery and coopery. The smaller rods and twigs are made into baskets. The bark is used for tanning.

Drawing and composition to follow.

## THE EFFECT OF LIGHT ON PLANTS.

**Things required.**—*Specimens of all the plants mentioned in the lesson; apparatus and material as specified for the various experiments. Note that in some cases the experiment must be commenced three months before the lesson is given.*

### ROOTS.

1. Show any young seedling plant. Cleanse its roots. The root is colourless, but the stem and leaves are coloured.

2. Grow a potato plant *in the dark*, or in a dark house. Grow another specimen synchronously *in the light*. Let class compare. If several specimens be grown in each case and the potatoes boiled, those grown in the light will be 'flowery,' whilst the others will be 'watery.' Take one of the specimens grown in the dark and bring it into the light. It begins to develop at once. If the specimens grown in the dark are not removed in time they become blanched and die.

3. Grow some potatoes with a diminished supply of light—in an orchard or under trees. Boil some of the potatoes thus grown. They will again be found to be watery, because of the small quantity of starch produced. **Light is necessary for the proper growth of starch.**

4. Show any *underground root* (except such roots as carrot and beetroot); it is colourless. Show also any *aërial root*; it is *not* colourless. **Light is necessary for the production of colour in the plant.**

### LEAVES.

1. Show any ordinary freshly plucked leaves. The under side is paler than the upper side **because it is turned from the light more than the other side.**

2. *De Candolle's Experiment.*—'If we take three plants in leaf, of the same species, of the same size, and of the same degree of vigour, and place them, after weighing them carefully, in close vessels—one in total darkness, the other in the diffused light of day, and the third in the sunshine—and prevent absorption by the roots, we shall find that the plant exposed to the sun has lost a great quantity of water, that in common daylight a less amount, and that which was in total darkness almost nothing.'

3. Grow two similar plants and cover each with a glass bell jar, or something similar, so as to make rough Wardian cases. Keep one in the dark and the other in the sunlight. Little or no moisture is given off from the leaves of the specimen kept in the dark, much from the specimen grown in the light. **Evaporation goes on best in the light.**

4. Take any green-leafed plant which has been grown in the light and place it in the dark. **The leaves soon fall of.** Keep it in the dark for some time. If other leaves grow they will have a whitish or yellowish colour.

5. Conversely, grow a plant in the dark. Remove it to the light. The leaves soon lose their whitish hue and become green. Also note that **the leaves grown in the dark are remarkably small.**

## BLANCHING.

1. Grow some *celery* freely exposed to light and unbanked, and note :—

   (*a*) The stem is coloured.
   (*b*) It is woody, tough or stringy.
   (*c*) The taste is unpleasant.

This is through the formation of peculiar and (to man) injurious secretions in the plant under the action of light.

2. At the same time bank another growing specimen in the customary way, and note :—

   (*a*) The stem is white.
   (*b*) It is neither woody, tough, nor stringy.
   (*c*) The taste is pleasant.

The outside stalks might also be compared with the 'heart,' or inside stalks. Being more or less exposed to light, the outside stalks approximate more to (1) than (2).

## WEIGHT.

1. Grow a *garden nasturtium* in the dark and another specimen in the light. The former specimen is about one-twentieth to one-thirtieth the growth of the latter.
2.

| I. | II. | III. |
|---|---|---|
| Grow 4 seeds of Indian cress. | Grow 4 seeds of Indian cress. | Grow 4 seeds of Indian cress. |
| Put in the dark. | Put in diffused light at a west window for 7 hours every morning. | Keep in a west window with direct sunlight every afternoon. |
| **It loses weight and dies.** | **Will sprout and in 3 months will gain weight.** | **Will sprout and in 3 months will gain about 4 times as much weight.** |

Drawing and composition to follow.

## AUTUMN TINTS.

**Things required.**—*Specimens of all the leaves mentioned in the lesson. Summer specimens should be collected and pressed for comparison in an autumn lesson ; similarly, autumn specimens should be pressed for comparison in a summer lesson.*

OUTDOOR WORK.—The Outdoor Work should include visits to all the plants, specimen leaves of which are used in the classroom work. The specimen leaves for the school lesson should be collected on this visit. Call attention to the beautiful effect of the autumn tints.

CLASSROOM WORK.

1. Recapitulate the lesson on the *Effect of Light on Plants*, and so remind the class that **light has a powerful influence on plants with respect to colour.**
2. Show specimen leaves of the *poplar, ash, beech, white grape vine, maple, birch, elm, sycamore*. The leaves are all more or less **yellow**.

It is not expected that the class will be able to visit every one of these specimens. But it *is* advised that *all* the specimens the neighbourhood affords should be viewed.

3. Show specimens of the *holly*, *box*, *ivy*, or other evergreens. The leaves are still **green**, but even they are paler than in the summer.
4. Show specimens of *rhus*, *creepers* (some), *dogberry*, *blue grape vine*, *any plants with red fruits*, *sycamore*. They are all more or less **red**.

   It will be noted that the sycamore is included under the yellow and the red. As a matter of fact the leaves vary very much, changing from a green to a tawny colour, and eventually becoming scarlet.

5. Show specimens of the *oak* and *hornbeam*. They are **brown**.

*What causes these leaves to change colour?* The causes are not definitely known, but it is believed to be due to **the change of the green colouring matter into other substances.**

6. Show a set of specimen leaves of the *sycamore* or any other suitable plant. For this purpose it will probably be necessary to collect the earlier specimens and press them so as to compare them with the autumn specimens. Note :—
   - (*a*) The young leaves and the mature leaves are **green.**
   - (*b*) Later specimens are **greenish brown.**
   - (*c*) Specimens decomposing (autumn) are **bright orange brown.**
   - (*d*) Final specimens are more or less **dull brown**, *i.e.* **the colours change as the leaves get nearer their death**; or the leaves show different colours according to their vitality?

Composition to follow.

## THE FROG (First Lesson).

**Things required for all three lessons.**—*Specimen frogs (kept moist). The frogs should be kept in a large covered glass dish with a little damp grass or water at the bottom; a skeleton of the frog; frog spawn and young tadpoles showing the stages of development; a piece of frog's skin; a picture showing the stages of development; a pail or any large vessel filled with water; pictures of the swallow or goatsucker (B.B. sketches would be better, only the head need be sketched); the upper jaw of a frog; a tadpole and a frog already prepared to show the internal organs; heart and swim bladder of a fish; pair of bellows, a worm.*

Outdoor Work.—Towards the end of March or early in the spring *several visits at intervals of some days might be paid* to collect all the specimens required.

1. Drag the bottom of the pond with a net. Among other things brought up will be some little black eggs. Note that they are coated with jelly.
2. Look for others which have risen and are floating about on the surface of the water. Note that these are bigger. The jelly has swelled very much by the sucking up of water, and this has caused them to rise.
3. Look for later specimens on the surface of the water, and note that the eggs are gradually taking a fish-like shape.
4. About ten days after the eggs were laid the head, body, and tail of the young tadpole, which has forced its way out of its sheath, may be distinctly seen.

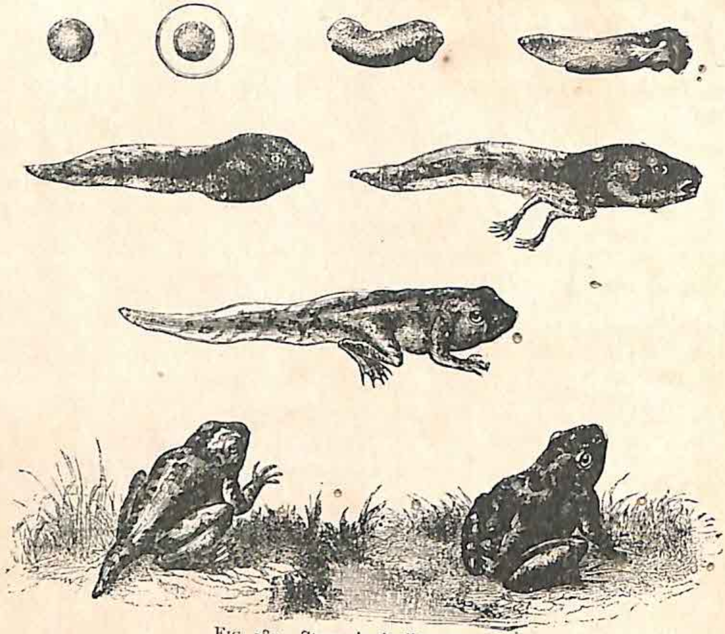


FIG. 187.—Stages in the life of a frog.

Examine this carefully, and note :—

(*a*) There is no mouth.

(*b*) There is a pair of suckers under its head.

5. Look for specimens a few days older. They now have mouths. Note the three pairs of outside gills which are fringe-like in appearance.
6. Soon after the three pairs of outside gills shrivel up, and an inside pair has grown, over which a fold of skin grows to form the gill-chamber.
7. An examination of a little later specimen will show that the gill-chamber has closed up and left but one opening, on the left side. At this stage note that the animal is all head and tail. Note that the eyes are beneath the skin.
8. Later specimens show that the tail gets smaller until it disappears. Four legs begin to grow out of the body, and the tadpole becomes a frog.

CLASSROOM WORK.*

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **MOVEMENTS.** | | |
| 1. Show a frog. Note that the two front legs are short, the hind ones long and muscular. | Compare with the kangaroo and rabbit. It hops about fields and gardens in the summer. | **The legs are favourably formed both for jumping and swimming.** |

---

* The teacher might get some frog-spawn, and the frog could be developed in the class-room.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. Put the frog in a pail of water and ask the class to note the action of the hind legs. | Compare with the action of a boy when swimming the breast stroke. | **Long hind legs give a powerful 'kick' in swimming.** |
| 3. Show the skeleton of the frog, and note the *absence of ribs*. | | **The absence of ribs is favourable to leaping.** |

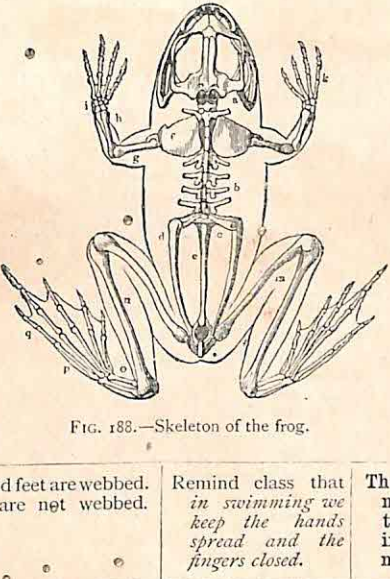


FIG. 188.—Skeleton of the frog.

| | | |
|---|---|---|
| 4. Note that the hind feet are webbed. The forefeet are not webbed. | Remind class that *in swimming we keep the hands spread and the fingers closed.* | **The web feet offer more resistance to the water, and so increase the swimming power.** |
| 5. Call attention to the long ankle in the hind legs. | | **The long ankle adds power to the feet for swimming.** |
| 6. Let the children feel the skin of the frog; it is soft and slimy. | Compare with the slippery surface of the body of a fish. | **Its smooth and slimy skin enables it to slip easily through the water.** |
| 7. Let the children note the temperature of the frog; it is cold. The frog has cold blood. | *Our* bodies are warm because our blood is warm. | **Its cold blood enables it to stay a long time in the water.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 8. Show a tadpole (tailed poll, *i.e.* all head and tail). Note its long tail and pair of suckers. *It fastens itself to the floating weeds by means of its suckers.* | As the tadpole grows the tail is more and more used, and less use is made of the suckers. | **The large tail is a powerful swimming organ.**<br>**The suckers are resting organs.** |
| 9. Show the frog again. Note that it has no tail. | The tail disappears as the legs grow. | **The hind legs answer the same purpose in the frog as the tail in the tadpole.** |
| 10. Note the hump in the middle of the back. | This hump is caused by the hip bones meeting the spine. | **The large hip bones help the frog in jumping.** |
| 11. Note the frog at rest; it sits half upright. | Compare with kangaroo. | |

Drawing and composition to follow.

## THE FROG (SECOND LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **CAPTURE OF PREY.** | | |
| 1. Note the wide mouth and long tongue. Feel the tongue; it is sticky. | The frog is fond of flies and snails, and will even eat bees, wasps, worms, and slugs. | **The wide mouth favours the capture of its insect food.**<br>**The sticky surface of the tongue causes the insect to stick to it as soon as the tongue touches it.** |

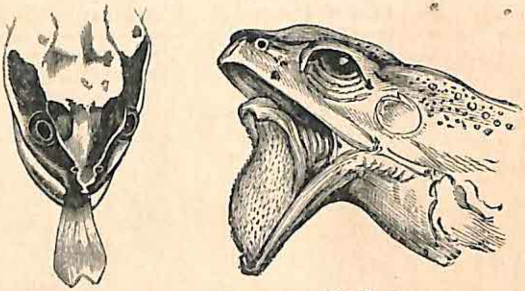


FIG. 189.—The tongue of the frog.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. Note that the tongue is not fastened to the back of the mouth like ours, but is fixed in the front with the tip going backwards.<br>The frog is an insect eater. Compare its wide mouth with the wide beaks of insect-eating birds, like the swallow and goatsucker. | | **The way in which the tongue is fixed in the mouth enables it to be thrown out rapidly.** |
| 3. Show a piece of frog's skin to the class. Let the boys feel it; it is dry. Now place it on some well damped grass. It rapidly sucks up the moisture. The frog does not drink through its mouth. | In times of drought they bury themselves in moist places. | **The frog drinks through its skin.** |
| 4. Note the large, prominent eyes. | | **The frog requires quick eyesight to catch flies.** |
| 5. Note there is no distinct neck. | | **A narrow neck would make the swallowing of insects difficult or impossible.** |
| 6. Note the tightly stretched black drum of the ear on each side of the head just behind the eye. | The tightly stretched drum makes the frog quick of hearing. | **A quick ear is necessary both in seeking food and in avoiding foes.** |
| 7. Show the teeth; they are only in the upper jaw and are very small. Note that they are sharp and bent backwards. There are no cutters and no grinders.<br>Note further that there are two little groups on the roof of the mouth, and a single row in the upper jaw.<br>They are replaced when worn out or lost. | The head of a frog should have been previously prepared to illustrate 7, 8, and 9.<br>Compare with the teeth of the snake.<br>Elicit that we have two sets of teeth, and when we lose one of the latter set it does not grow again. | **Like the snake's teeth those of the frog are formed for holding. The teeth are principally used for eating worms.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 5. Show some eggs from which the jelly has been cut away, and which have been kept in the warmth. Note that 'water-moulds' have grown on them. | The eggs have not hatched, and the 'water-moulds' have helped to kill them. No 'water-mould' grew on the jelly-clad specimens. | **The eggs cannot hatch without the jelly.** |

Drawing and composition to follow.

## THE SNAIL (FIRST LESSON).

**Things required.**—*Specimen snails* (*children might be invited to bring them*); *snails' eggs and young snails in various stages of growth ; a snail's shell sawn through lengthwise ; some water with powdered chalk already in it ; a large piece of glass ; a glove or a sock ; a rasp or file, and a bit of sole-leather or wood.*

OUTDOOR WORK.—The children may look for a snail in gardens, or under stones and moss at the roots of trees, or among fallen leaves, or nettle beds in damp and shady places. It hides under leaves or stones during the day and comes out at night, and after rain. Its eggs must be sought for in the spring in damp places below the ground. Each egg is about the size of a small pea, is a soft, jelly-like little body, and the young snail may often be seen within, through its half glassy-looking walls. A baby snail is a minute creature with a tiny shell, looking like a glass bead. The specimens should be preserved in boxes with a leaf or a few blades of grass.

CLASSROOM WORK.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **SHELL.** | | |
| 1. Show shells of various sizes—snails in various stages of growth. | Compare the shells with those of the whelk, periwinkle, &c. | **The shell grows larger as the snail grows.** |
| 2. Let the class examine the shells. There are a number of lines passing round them. | The older the shell the greater the number of lines. | **These lines mark out the new layers as they are formed.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. The young snail with the edge of this skin sweats out of its body a thin, vapoury-looking fluid. | This fluid contains chalk, and the fluid dries up, leaving the chalk behind, as shown in 4. | **These layers are formed of chalk, which comes from the snail; so that the snail, like the spider, builds its home out of the products of its own body.** |
| 4. Show the class some chalky water, and boil off the water over a gas flame or a Bunsen burner. The chalk is left behind. | | |
| 5. Show the shell which has been sawn through lengthwise, and note the spiral coil, the top of the shell (spire), the central column, called the little column, and the opening for the snail to come out. | The snail cannot live without its shell. | **The shell is built from the spire downwards round the little column.** |

## MANTLE, BODY, FOOT.

| | | |
|---|---|---|
| 1. Recapitulate 3 under 'Shell,' and observe that the mantle lines the shell. | It will be necessary to cut off with scissors three-quarters of the first turn of the spiral to expose the mantle. | **The secretion of the slime is very necessary, because the snail cannot live with a dry skin.** |
| 2. Call attention to the colour of the shell; it varies. | | **These colouring matters are found in the slime.** |
| 3. Point out the lung slit, and note that the mantle follows the coils of the body, and encloses the lung slit. The mantle is full of blood-vessels. | Show the suitability of the name 'mantle,' and name other '*mantle bearers*' (*slug*, &c.).<br>Compare with our lungs. | **This brings the blood in close contact with the air for the purpose of purifying it.** |

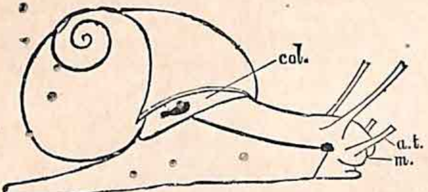


FIG. 190.—External characters. *a*, *t*, front feeler; *col*, collar; *m* mouth.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 8. Try to get the frog to eat a worm. | Let the class note that in eating the worm the frog uses its paws (front) and pushes the worm into its mouth with them. | **The frog swallows its food whole, and neither bites nor chews it.** |

The tadpole feeds only on vegetable food (weeds). When it ceases to eat weeds *its body is fed by its tail*, wandering little blood vessels carrying the food from the tail to the body. When the supply of food from the tail is all gone the tadpole becomes very hungry, changes its food, and now feeds on animal matter. Tadpoles are always hungry at this stage, and sometimes eat each other.

## THE FROG (THIRD LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **BREATHING.** | | |
| 1. Show a tadpole, and point out its three pairs of gills. | Then the tadpole has gills like a fish. | **The tadpole can live under water like the fish, because it breathes like the fish.** |
| Now take the prepared frog; it has no gills, but it has lungs. | The gills have disappeared, and lungs have grown. | **The frog breathes through its lungs, and, therefore, like us, cannot remain under water long.** |
| 2. The principle of a frog's breathing can be fairly well illustrated by a pair of bellows. | Keep a frog's mouth open long enough and you would choke it, for the air could not be forced into its lungs. | **The frog swallows the air just as we swallow our food.** |
| 3. The skin is full of very little holes (porous). | The skin must be kept moist or the little holes would be closed by the shrivelling of the skin. | **The frog breathes by means of its skin as well as its lungs.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 4. Show the skeleton of the frog. It has no ribs. Ask the class to breathe deeply and to note the action of their ribs—*we use our ribs in breathing.* | In the winter, when below the surface, it must breathe somehow. | **The frog must breathe differently to us.** |

## WINTER QUARTERS.

| | | |
|---|---|---|
| No frogs are found in the winter.<br>Drag the mud at the bottom of a pond and a lot may be found together.<br>Some may be found in holes in the ground. | Compare with snake, hedgehog, &c. Whilst asleep certain parts of the body (fatty bodies) become smaller.<br>The frogs wake up in March, and soon begin to lay their eggs. | **The frog sleeps all through the winter, and nourishes itself on its own body.** |

## DEVELOPMENT.

| | | |
|---|---|---|
| *Recapitulate the Outdoor Work.*<br>1. Note the colour of the eggs—black. | Question on the theory of black and light clothes. | **The eggs are black to absorb the heat as they float about.** |
| 2. Show the result of keeping eggs—<br>(*a*) In light and warmth.<br>(*b*) In darkness and warmth.<br>(*c*) In a cool place.<br>The first two have hatched; the latter not. | This experiment must be commenced some days before the lesson is given. The eggs should be kept in water. | **Warmth, but not light, is necessary for hatching the eggs.** |
| 3. Note the coating of jelly. Handle the eggs; the jelly makes them very slippery. Note the large number of eggs, and that they are all joined together. | Only ducks can eat frogs' eggs. Their broad bills enable them to do it; but it is not an easy task even for them. | **The slippery coat of jelly protects the eggs from being devoured. It also prevents them from crushing each other, and from shutting out the air in the water from each other.** |
| 4. *Why does the frog lay so many eggs?* | Many of the young are eaten by the dragon fly and other water insects. Many are eaten by birds as soon as they take to land. | **Because frogs have so many enemies.** |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 4. Show the coiled shell. Call attention to the coil again. | The body fills the shell. | Therefore the body must be coiled. |
| 5. *Why is the body coiled?* | Compare with *periwinkle, whelk,* &c. | Because the animal grows rapidly on one side and not on the other, or only very little. |
| 6. Examine the body of the snail; it is soft and fleshy. | When doing 9, get the class to notice:—<br>(*a*) The wavelike motion of the foot.<br>(*b*) The action of the fleshy disc.<br>(*c*) The slimy track left by the snail.<br>The slug sometimes descends from a tree by the aid of a slimy thread, which hardens on contact with the air. | The snail has no bones. |
| 7. Show the underside of the body; it is composed of a fleshy, muscular disc. | | The wavelike motion of the 'foot' and the muscular contraction of the disc, give the snail its well-known gliding motion. |
| 8. Note the foot under the body; it is long, pointed, and turned towards the back part of the animal. | | |
| 9. Place the snail on a large piece of glass, and hold it so that the children can see the method of progression *through the glass.* | | |

Drawing and composition to follow.

## THE SNAIL (SECOND LESSON).

OUTDOOR WORK.—Recapitulate.

CLASSROOM WORK.

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| **HEAD, EYES, HORNS.** | | |
| From an examination of the snail—<br>1. Note that it has a distinct head. Touch the head; it disappears. | The horns are hollow and a muscle runs up the inside. By a contraction of this muscle the eye can be withdrawn within the horn. Illustrate by drawing the tip of a glove finger down from the inside, or by drawing in the foot of a sock in a similar way. | The head can be withdrawn within the shell. |
| 2. Note the four horns or feelers on the head, the upper pair being the longer. Touch them; they are withdrawn from sight. | | This power of withdrawing the head, horns, and eyes is a means of protection to the snail. |
| 3. Point out the eyes at the end of the long pair of feelers; one eye in each. | | The eyes being placed at the end of the feelers enables the snail to see in all directions. |

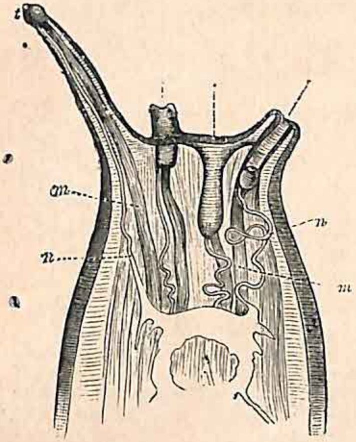


FIG. 191. – Diagram of the head of a snail. *n*, nerves; *m*, muscles; *t*, feelers.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **FOOD.** | | |
| 1. Point out the mouth and examine it; the jaws are horny. | | |
| 2. Describe the tongue. It is rough and ribbon-like, and is fastened to some gristle by muscles. The tongue grows forward as the teeth are worn out. Illustrate the action of the teeth by a rasp or file on a bit of sole-leather or wood. | The rough feeling is due to 'teeth,' of which the snail has 14,175. The slug has over 26,000. | **The tongue is formed for boring and rasping its vegetable food.**<br>**The muscles fastened to the gristle also enable it to act as a lapping organ.**<br>[Compare with the lapping of a dog or cat.]<br>**The growing forward of the tongue keeps it always in working order.** |
| 3. Tell the class that the snail has a heart, digestive canal, and nervous system. | The nervous system is in the form of a ring round the fore end of the digestive canal. | **As with us, the heart pumps the blood all over the body.** |

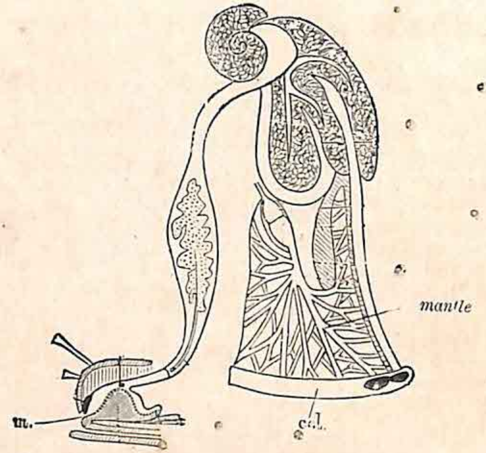


FIG. 192.—Snail dissected. *col*, collar ; *m*, mouth.

## WINTER QUARTERS.

The snail sleeps through the winter. (*Ask class to name other winter sleepers.*) As soon as the autumn days get cold it retires to a crack in an old wall, to a thatched roof, beneath the roots of a tree, or some other snug and warm position. It then forms a sort of skin over the opening of its shell—sometimes two or three skins, or screens. (*This is done for protection and warmth.*) It always leaves a little opening in the skin. (*For air. Why want air?*) A snail that has retired for the winter may be speedily brought back to activity by being placed near a fire. It has the power of growing again any damaged or missing part.

### B.B. SUMMARY.

Rapidly recapitulate both lessons for these facts.

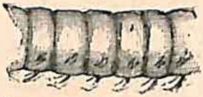
1. The snail lives in a shell.
2. Its body has no bones and is coiled.
3. The part of the body inside the shell is covered with a 'mantle.'
4. It moves with a gliding motion.
5. It can see and feel.
6. Its tongue is formed for boring and rasping.

Drawing and composition to follow.

## THE EARTHWORM (FIRST LESSON).

**Things required.**—*A few specimen worms; a worm already dissected; a large box of loose mould (the mould in the box should be kept moist); a pencil sharp at one end; a dead worm; a bowl of water and a lens; a sharp penknife.*

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **SHAPE.** | | |
| 1. Show a specimen worm; it is long, tapering from the middle forwards, with a slight bulge in the front part. | The worm may reach a foot in length. | **Its shape adapts it to burrow and to live underground.** |
| 2. Note that one end is more pointed than the other. Watch its movements; it always travels with this pointed end first. | *If any noise is made a worm at once dives back into its hole.* This might be tested on some suitable evening by the children themselves. | **The pointed end must be the head.** |
| 3. Note the absence of limbs. | | **The absence of limbs is favourable to burrowing.** |
| 4. Place worms on the mould in the box. If they dig, ask class to note that they dig with the head. | The worms keep *underground during the day*; even at night if you produce a light they at once disappear. | **It is to the pointed shape of the head that the worm owes its digging power chiefly.** |
| 5. Compress some mould into a harder mass, and let some of the children insert the pencil into it; first the sharp end, then the blunt end. *The sharp end goes in the easier.* | *There must be some sense of smell*, for they manage to distinguish their favourite food and to show a difference between red and green cabbage. | |
| 6. Show the mouth just beneath the head. Call attention to the various live specimens; the head is all the while moving about. Note the *absence* of nose, ears, and eyes. | Their *sensitiveness to motion* is utilised by men who want worms to fish with. The men stick a spade in the ground and the worms immediately come to the surface. | **There are no special sense organs, but the worm**<br>**(*a*) Is somehow aware of sounds;**<br>**(*b*) Can evidently smell;**<br>**(*c*) Is very sensitive to motion;**<br>**(*d*) Seems to have some sense of touch; and**<br>**(*e*) Is shy of light.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **RINGS.** | | |
| 1. Show the specimen worms, and let the class note that the body is built up of a large number of rings. | The total number of rings is over 120. | |
| 2. Note that the front rings are much larger and fuller than the hind ones. | <br>FIG. 193.—A worm's hooks. | **From what has been said of the worm regaining lost parts it might be inferred that you may cut a worm to pieces and that each of its parts is capable of an independent existence. This is not strictly true. Cut a worm in halves, and the hinder part soodies, although the front part will probably live and its wound heal. Again, if you cut away the first few segments, that portion will soon die, and the larger and remaining part will recover and live.**<br>[These facts are to be told to the children.] |
| 3. Count down to the fourteenth or sixteenth ring. There is a fleshy swelling, convex above and flat and porous below. | | |
| 4. Wash a worm in a bowl of water, lay it on its back, and put a lens over it. Note some very small hooks or bristles, eight for each ring, there being four double rows. | The class should note that the bristles are all on the under part of the worm. From the presence of these little hooks the worm may be said to be bristle-footed. | |
| 5. Let the children move the fingers along the worm's body from the tail to the head; the bristles can be felt. | | |
| 6. Cut a longitudinal section of the dead worm and show that the body is divided by cross partitions into segments which correspond to the external rings. | Its power of regaining lost parts is very remarkable. A worm is not only able to survive the removal of the forepart of the body, including the brain, mouth, &c., but in less than two months has been known to have completely replaced them. | |

Drawing and composition to follow.

## THE EARTHWORM (SECOND LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **LOCOMOTION.** | | |
| 1. Ask children to note that all the bristles point backwards. | | **It moves, burrows, and digs by the aid of its bristles.<br>The bristles prevent the worm from slipping out of the opening it digs.** |

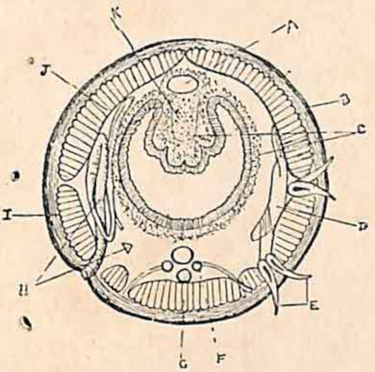


FIG. 194.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. Draw fig. 194 on B.B. to show the layer of circular muscles. | The circular muscles are connected with the bristles. The worm contracts these muscles, sticks its bristles like pins against the ground, and so, contracting and lengthening different parts of its body, thus moves along the surface of the ground. | |
| 3. Take a live worm and let the children feel it. It is moist or slimy. The slime is continually issuing from the pores of its skin. | | **The slime keeps the body moist and so prevents the mould from clinging to it.** |
| 4. (*Tell* this experiment.) Place a worm in some dust or in a warm sun on a dry surface. The worm soon dies. | | **From 4 we see that the slime is necessary to its existence. The dust stops the action of the pores of the skin, or the sun causes the slime to evaporate too quickly.** |
| 5. Keep the worms on the damp mould. If any begin to dig ask class to note the contractions and lengthenings of the body. | | **Summing up, we now see that the burrowing is aided—<br>1. By the pointed head;<br>2. By the slime;<br>3. By its habit of shovelling the earth into its body by means of its lip;<br>4. By the bent-back hooks.** |

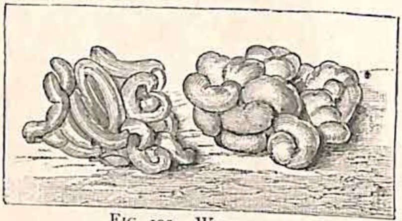
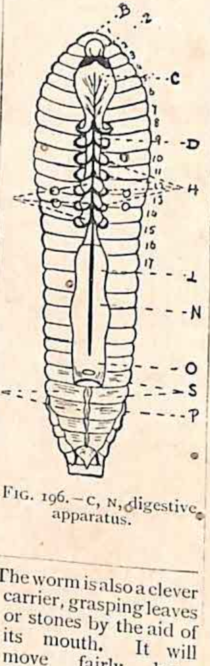


FIG. 195.—Worm casts.

## FOOD.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES, &C. |
|---|---|---|
| 1. Take the dead worm and with a sharp penknife and a pin lay open its mouth. Feel for the teeth. |  B<br>2<br>3<br>4<br>5<br>C<br>6<br>7<br>8<br>9<br>D<br>10<br>11<br>12<br>H<br>13<br>14<br>15<br>16<br>17<br>L<br>N<br>O<br>S<br>P<br>FIG. 196.—C, N, digestive apparatus. | If there are no teeth, then how does the worm grind up its food? It carries little stones in its stomach, which grind up its food. [Compare with birds.] |
| 2. Let the class feel the worms again; the body is soft. Take up a worm and gently stretch the body; it stretches easily. | | From 2 we infer that its body will hold plenty of earth, which is favourable to its digging. |
| 3. Take the dissected worm and point out the wide digestive tube. (*A flat-bottomed, shallow vessel should be used. The bottom should be coated with a little paraffin wax so as to enable the pins to stick. A little water should then be poured into the dish, the worm should be carefully cut down the dorsal side and carefully pinned out.*) Note that the gizzard or stomach is about eighteen segments behind the mouth. | | Tell the following facts:—<br>The worm feeds on earth, dead leaves, stalks of plants, carrots, celery, onion, horseradish, and animal matter.<br>In dry weather it digs deep down till it comes to moist earth. It is such a powerful digger that it can even make its way through a hard gravel walk.<br>Its food is moistened by a kind of slime, ground up by the little stones in its muscular stomach, digested in the intestines, and what is then left is thrown up on the ground as 'worm-casts.' |
| 4. Take a live worm and point out that the long digestive portion of the body is covered with yellow cells, which are well known to all who have stuck a fishing-hook through it. | The worm is also a clever carrier, grasping leaves or stones by the aid of its mouth. It will move fairly large stones along and use them to protect its burrow. It also drags leaves into its burrow, and seizes them in a way easiest to carry them. | |
| 5. The worm is very active at night, when it keeps its tail fixed in the mouth of its hole whilst it feels around for food. The number of worm-casts show its activity (fig. 195). | | |

## ITS USES.

Worms are probably the most useful of all animals. They plough the ground and fertilise it. Hence they are great promoters of vegetation, for their digging opens the way for the raindrops, for air, and for the rootlets of plants They thus help to drain the soil. They grind up the soil in their stomachs and liberate the elements. They probably help more than anything else to form vegetable mould, for they are incessantly drawing leaves, stalks, straw, and twigs into the ground. It has been shown that on an average there are probably 53,000 worms in an acre of garden, and that ten tons of soil annually pass through their bodies, and that they bring up soil to the depth of three inches in fifteen years. They also probably provide new soils for hills and slopes, where the rain is often washing them away. The 'worm-casts' form a splendid manure, and they are the salvation of pasture lands, for they bring up soil from below, as has been shown, to a relatively enormous extent.

Drawing and composition to follow

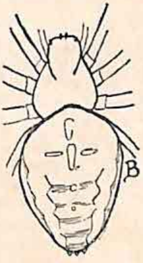
# THE SPIDER (Compared with the Bee).

## (FIRST LESSON.)

**Things required.**—*Specimens of the garden spider and the bee pinned out on cork; a spider's skin previously prepared; lens; a dissected spider; some threads and spokes of a spider's web.*

OUTDOOR WORK.—In one of the school rambles the attention of the children could easily be directed to the examination of the spider's web, and to the work of the bees on the various flowers. Any hives in the neighbourhood might also be visited.

CLASSROOM WORK.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **SHAPE.** | | |
| 1. Hand round specimens of the *spider* for examination, and note that the *body* consists of *two parts*; the head and chest forming the front part, and the abdomen or belly the hind part. The two parts are joined by a narrow neck. |  FIG. 197.—The spider's body. | **The bee is an insect, and therefore the spider, which is differently constructed, is not an insect.**<br>**The class should notice that nothing is said about touch, smell, or hearing, the inference being that these organs seem to be lacking.** |
| 2. Next hand round specimens of the *bee*, and note that the body consists of *three parts*: head, chest, and abdomen. | | |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. The spider's *skin* is soft and leathery. The bee's is hard. | The spider's skin is cast at irregular intervals during life.<br>The hind part of the spider contains the digestive organs as well as the spinnerets. | **A soft skin is necessary for an animal living on such a delicate structure as a web.** |
| 4. Point out the *spinnerets* and note the *yellow cross* on the lowest part of the back. | The entire body of the spider consists of twenty segments, the first six of which form the head. | |
| 5. Note that the *bee's* body is divided into *segments*. In the spider's body the segments are not so distinguishable. | The female spider is larger and fiercer than the male. | |
| 6. The *eyes* are in the front segment, and that they are generally arranged in two rows. This will be seen by the aid of a lens. | The eyes are never compound (explain compound if necessary). The eyes look like small bright specks. | **The two rows of eyes enable the spider to see in all directions at once.** |
| 7. The eyes are protected by a horny transparent substance. | | **Hence no necessity for eyelids.** |

## LEGS.

| | | |
|---|---|---|
| 1. Count the spider's *legs*; there are four pairs. Note that the legs are very long, and that the first and second pairs are longer than the others. | An insect always has three pairs of legs. | **As the spider and the bee differ both in the formation and number of their legs, the inference again is that the spider is not an insect.**<br>**The long legs are required for speed to capture its prey.** |

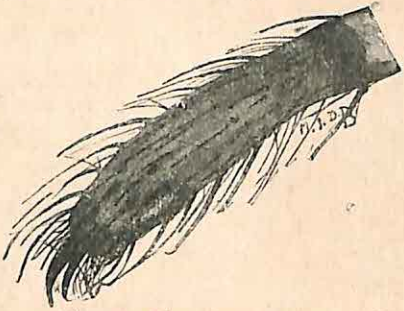
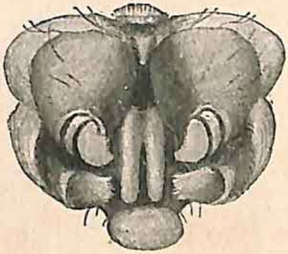


FIG. 198.—Claw of garden spider.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. Put the lens over one of the *legs*; it is made up of seven pieces. Look at the ends of the legs and note the formidable looking claws. Note that the hind claws are made like a pair of combs. | When spinning, the thread passes between the two hind legs. | The spinning is regulated by these combs. |
| 3. Examine the bee's *legs*, and note that there are three pairs, with five pieces in each and claws at the end. | <br>FIG. 199.—Jaws of garden spider. | |

## JAWS.

| | | |
|---|---|---|
| 1. Sketch *jaws*, and note that each jaw consists of two pieces, the outer of which is made like a claw and can be folded back into a groove. Illustrate with a pocket knife. | Down each jaw is a tube which leads to the poison bag. The poison is harmless to us. | The jaws are modified feelers, and are the spider's chief weapon of attack.<br>The poison benumbs, and then poisons the insects. |
| 2. Examine the head of the *bee*; there are two horns or feelers. | | |

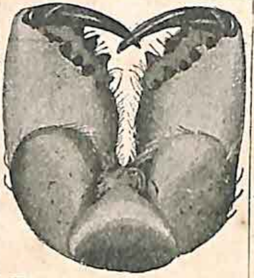
## BREATHING.

| | | |
|---|---|---|
| 1. The little lung sacs open on the under surface of the body towards the front. Note that they are two or four in number, and each opens on the surface of the belly. | Each sac consists of an infolding of the skin, in which there are a number of flat plates with their flat surfaces placed together like the leaves of a book. Some spiders have air tubes also. | The blood-vessels of the lungs branch out on these plates, and so the blood is brought close to the air to be purified through their very thin walls. |

Drawing and composition to follow.

# THE SPIDER (Compared with the Bee).

## (SECOND LESSON.)

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **SPINNERETS.** | | |
| 1. The spinnerets are cone-shaped and vary in number according to the specimen, from four to eight. The bee has *no* spinnerets. |  | **The spinnerets are the most distinctive features of spiders as a class.** |
| 2. There is a large number of holes in each spinneret. | FIG. 200.—Spinnerets of the garden spider. | **The web of the garden spider is more often destroyed than that of the house spider; hence it would be necessary to rebuild it quickly. It also covers a larger area.** |
| 3. The silk glands are connected with the spinnerets. | These silk glands are filled with a sticky fluid of a pale, yellowish colour, which hardens on contact with the air. Compare with the *slug*. | |

4. *Describe the process of spinning.* When a spider begins to spin it *contracts* these glands, and so forces the sticky fluid into the spinnerets. It then *touches the surface of some fixed body with the tip of a spinneret*, and leaves a tiny drop of the silk fluid on it. Then it moves away quickly, drawing the thread out as it goes. This thread hardens at once on coming in contact with the air. At the same time the silk is forced through all the little holes, so that hundreds of delicate threads are formed. The comb-like claws on the hind feet press the strands together, as they are spun out, and so the complete thread is finished. The spinnerets are also used to make a stout thread to descend from heights, as in the slug.

5. They are also used to capture prey; *e.g.* when a fly or other victim is entangled in a web, if it is small, weak, or harmless, the spider rushes out, touches its body with one of its spinnerets, seizes it with its claws, begins to turn it round and round, and at the same time to spin a broad ribbon-like band*—not a single thread—so that in a few moments it is *bound* into a state of complete helplessness. Meantime it has also bitten its victim with its terrible poison jaws. Thus the fly is doubly helpless, and in that state it is sucked dry of all the juices of its body, for it is these juices that constitute the chief food of the spider. If the victim is a big bluebottle, a bee, or a wasp, the spider generally cuts a few threads of its net and lets them escape. Thus the *spider* eats animal food, but the *bee* eats vegetable food (pollen, nectar).

---

* Note the suitability of this special act. The victim requires to be bound quickly; hence the band and not the thread.

The way in which the spider gets its food shows it to be sly, crafty, bold, active, savage, and greedy. Its boldness and savagery are shown by the way in which it will attack larger insects than itself; its craft in letting bees and wasps alone.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **WEB.**<br>1. From the outdoor work the children will have noticed that the web of the common garden spider—<br>(*a*) Is circular. | <br>FIG. 201.—The garden spider. | |
| (*b*) Is made of two different kinds of thread.<br>(*c*) Is a spiral built on a framework of rays or spokes. | The examination of the threads should be done with the aid of a lens. Some threads and spokes should have been brought in for classroom work. | |
| (*d*) The spiral thread is more elastic than the spokes, but the spokes are the thicker.<br>(*e*) The spokes are studded all over with little beads of a sticky nature.<br>*Note* :—<br>Sketch a diagram of a web on the B.B., building it up line by line, and explaining as you go. Put in the outer lines first, then the spokes, and then the spiral. | Compare the spokes with the spokes of a wheel. There is one of these little beads at every point where the spiral crosses the spokes. | **The elastic nature of the threads is necessary to enable the web—the great bulk of which is composed of threads—to withstand the weather (rain, wind, &c.), and to resist the struggles of the spider's victims.**<br>**The spokes are thicker because they form the framework of the whole web, and therefore require to be strong.** |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 3. The sticky globules, like the sticky thread, harden on contact with the air, and therefore cease to be sticky. | | **They have to be frequently renewed (once in twenty-four hours).**<br>[It is not yet known how it is that the spider places these beads so regularly; nor how it is that it can run about over the web without being bothered by the thousands of sticky points.] |

4. The spider builds its web as follows :—' First it applies its spinnerets to a stem, and then walks away, leaving a fine thread behind it. A few paces off the tightened thread is fastened to another object, and then another line is formed. In this manner the creature continues to work apparently in a very irregular and aimless fashion, till it has stretched a number of threads from one projecting object to another, covering a wide area, but leaving a central space quite devoid of threads.

'These outer lines, though necessarily irregular on account of the relative positions of the points connected, are the foundation of the very regular and beautiful structure that is to fill up the blank within. The spider then decides on its central point, and spins a number of strong, radiating lines, all of which are double threads, from this point to the various parts of the foundation. . . . The spider next takes up a position in the centre again, and, applying its spinnerets to one of the radiating threads close to the point at which they meet, starts the construction of the spiral. It passes the tip of its abdomen quickly from thread to thread, at each movement laying a very elastic line, and gradually increasing the diameter of its spiral till satisfied with the dimensions of the snare.

'The building of the whole of this structure occupies less than an hour; and, the work being over, the spider retires to a neighbouring nook, where it can watch for its prey, and where, by means of a communicating thread, it can feel the vibrations of the web.'—*Furneaux.*

For its winter quarters it weaves a den or nest, to which it retires and sleeps until the spring.

Its eggs are not deposited in the web, but are put carefully away in some safe place, and the *egg-bags* may often be found on walls, fences, or under the loose bark of the trees.

## THE SPIDER AND THE BEE COMPARED.

### (Third Lesson.)

| Spider | Insect (Bee) |
|---|---|
| 1. The body is divided into *two parts*; the head and chest being united into one part, and the belly forming the other. | The body is divided into *three parts*; the head, the chest, and the abdomen. |
| 2. The segments *are not* distinguishable. | The segments *are* distinguishable |

| SPIDER | INSECT (BEE) |
|---|---|
| 3. There are eight *legs*, with seven pieces in each, and *claws* at the end. | There are six *legs*, with five pieces in each, and *claws* at the end. |
| 4. No *wings*. | Four *wings*. |
| 5. There are *eight eyes* (vary from one to eight) at most, and these are *simple*. | There are *thousands of eyes*, and they are *compound*. |
| 6. No *horns* (feelers), but *strong jaws* instead. | Two *horns*. |
| 7. No changes of form. | Three changes of form. |
| 8. Feeds on *animal* food. | Feeds on *vegetable* food. |
| 9. Poison *jaws*. | No poison *jaws*, but some have *stings* instead. |
| 10. Skin *soft and leathery*, and cast at irregular intervals during life. | Skin *hard*, except between the segments. Cast only in the larval stage. |
| 11. The breathing apparatus consists of little sacs opening on the under surface of the body towards the front. A few have air tubes also. | The breathing apparatus consists of tubes running through the body. |

**This comparison entitles us to say that the spider is not an insect.**

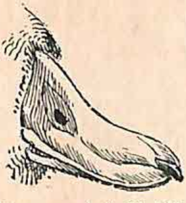
Drawing and composition to follow.

## THE BEAKS OF BIRDS (FIRST LESSON)

**Things required.**—*The head, beak or bill of the duck, fowl, parrot, and sparrow; goatsucker and heron also (if possible); a lens; a gizzard; pictures of the heron (waders) class.*

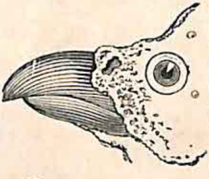
OUTDOOR WORK.—A visit should be paid to some ducks to watch their habit of feeding; fowls and sparrows come under daily observation. A visit to a museum or Zoological Gardens will most probably be necessary to see the goatsucker and heron. A pet parrot might be borrowed for the lesson; failing this, a museum must be visited as for the goatsucker and heron.

CLASSROOM WORK.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **DUCK.** | | |
| 1. Let class examine the duck's bill. Note that it is a long, broad, flat bill. |  FIG. 202.—A duck's bill. | **A long bill is suited for groping.**<br>**A soft bill for mud.**<br>**A broad flat bill for shovelling.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 2. With the aid of a sharp knife lay back the upper part of the beak (upper mandible), and show the cross plates and the fringe. Use a magnifying glass. | Large nerves go to these cross plates, which act as sensitive grasping surfaces | **A sensitive bill for feeling.** |
| 3. Let them feel the bill; it is soft. | | **From the fact that the bill is soft and supplied with touch nerves, it differs from every other class of beak.** |
| 4. Examine the tongue and each side of the bill; both are fringed like a comb. | These flat bills depend on this sense of touch, for they scoop up their food from the mud. | **The comb-like arrangement is for straining.**<br>**The muddy water runs out at the sides of the bill, strained through the comb-like arrangement, whilst the insects and the grubs are kept in the mouth.** |

## FOWL.

| | | |
|---|---|---|
| 1. Examine the fowl's beak. Note that it is only of moderate length. |  FIG. 203.—Head of numida. | **It does not have to grope in the mud like the duck.** |
| 2. Feel it; it is hard and horny. | | **It has to pick its food off the hard ground.** |
| 3. Look into the fowl's mouth; there are no teeth. | | **Hence the fowl cannot chew its food.** |
| 4. Show the gizzard. Note its strong muscles and hard ridges. The food passes through this gizzard before it reaches the stomach. | From time to time the fowl swallows small stones. By the action of these stones, the strong muscles, and the hard ridges, the food is thoroughly ground up. | **The gizzard acts like a mill.** |

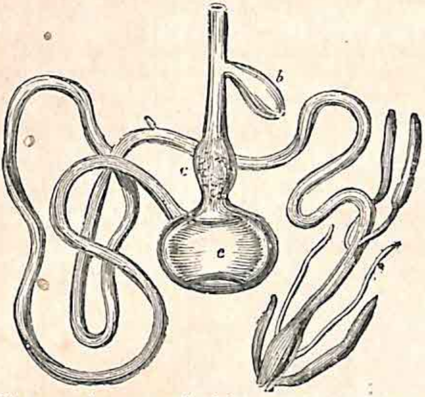
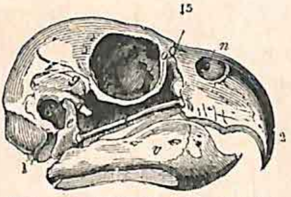
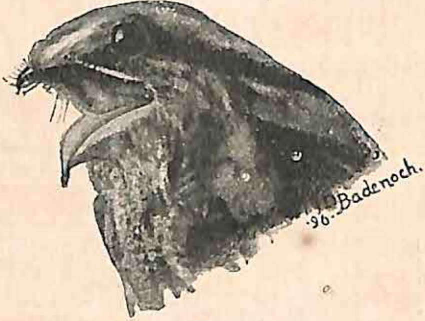
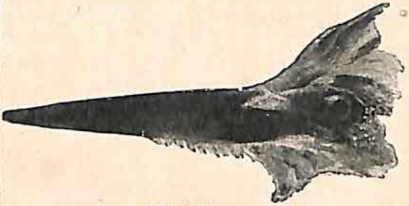


FIG. 204.—*b*, crop; c, glandular stomach; *c*, gizzard.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **PARROT.** | | |
| 1. Note that the beak is hooked and powerful. |  FIG. 205.—Skull of parrot, showing the hooked beak. | **The beak is used in climbing.** |
| 2. Note that the hooked upper part of the beak hangs a long way over the lower part, and that both parts are movable. | | |
| 3. Note the lower part of the beak; it is very short, strong, and deep. | By its peculiar movement against the upper part it can crush a nut. | **The stone crushing machines used in preparing stones for the road are made on the same principle as the jaws of the parrot.** |
| **SPARROW.** | | |
| Show the beak of the *common house sparrow*, and note that it is large and conical. | Sketch the beak on the B.B. | **Besides insects, these birds feed on grain; hence the bill is suited to break the seeds.** |

## THE BEAKS OF BIRDS (SECOND LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **GOATSUCKER.** | | |
| 1. Show the beak of the goatsucker. Note that the mouth can be opened to an enormous extent, in this case even beyond the eyes.<br><br> ·96· D Badenoch.<br>FIG. 206.—The goatsucker. | Or sketch on B.B. This bird is also known as the fern owl, churn owl, jar owl, spinner, and night-jar. | For this reason they are called cloven-jawed.<br>It is called the night-jar, because when perched it usually sits with its head lower than its tail and utters a jarring note.<br>It is called the spinner, because its long-drawn note was thought to resemble the sound of the spinning wheel. |
| 2. The examination of a live specimen would show the inside of the mouth to be covered with a sticky substance.<br>3. Look along the edge of the upper beak on either side; there is a row of bristles turned downwards. | It is a solitary bird, being generally alone, has a peculiar wheeling flight, and is seldom seen in the daytime, unless disturbed.<br>Other birds of this class are the *swifts, swallows, martins.*<br>This bird was called the goatsucker from a silly belief that it used to suck the milk from the goats. | This arrangement makes its mouth a sticky, bristly death-trap for insects.<br>[Illustrate with a piece of fly paper.] |
| 4. It flies with its mouth open and feeds on flying insects, such as cockchafers, gnats, moths, &c. | | If it feeds on these insects it must be a night bird. |
| 5. The open mouth gives a whirring noise when flying. | | This noise arises from the resistance of the air against the mouth. |
| 6. It comes in the spring and goes in the autumn. Note that insects come out in the spring and disappear in the autumn. | | It is only here whilst its food is to be had. |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **HERON.** | | |
| 1. Show a heron's bill or sketch on B.B.; it is a long, pointed, exceedingly sharp, powerful beak. |  FIG. 207.—Bill of the common heron. | |
| 2. Show the pictures of some birds of this class, and call attention to the long bills, long necks, and long legs. | | **Long legs, long necks, and long bills often go together. The length of the bill and the neck generally bear some proportion to the legs.** |
| 3. Note that the beak can open very widely, as far back as the eyes. | | **Hence it must be strong on the wing and have a long, wide-opening bill to strike a fish with certainty** |
| 4. It feeds on fish, frogs, snails, eels, toads, newts, &c. | When fishing it stands quiet, patient, motionless, in the shallow water; a fish is struck and swallowed in a second.<br>In time of frost it can exist for a long time on a very small quantity of food, but when food is plentiful it gorges itself repeatedly. It is calculated that one heron will destroy 15,000 carp in half-a-year. | |
| 5. It is a clever fisher and takes its prey by wading or by diving. The bill is aimed with great accuracy, and it always seems to strike the eye first. | It does its diving suddenly from the air, where it rests on its wings. | **To strike in the eye so swiftly a sharp and pointed bill is required.** |

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 6. When pursued it often disgorges its food. | | **To make itself lighter so that it can go faster.** |
| 7. Although so big a bird, and armed with a powerful beak, it will fly from the smallest of the falcon tribe, though a good fighter when driven to bay. | Other birds of this class are *bitterns, storks, adjutants.* | |

Drawing and composition to follow.

## THE FEET OF BIRDS (First Lesson).

**Things required.**—*Specimen feet of the duck, fowl, swift, owl, parrot; picture of the ostrich and heron (specimen feet of birds of the same class will do); picture of duck; fowl's leg, and a razor.*

Outdoor Work.—A visit to some local zoological gardens will be necessary to see the ostrich, heron, and owl. If there are no local pet parrots available they must be looked for there also. The duck and the fowl are under almost daily observation. Failing the opportunity to see the live animals a visit to a natural history museum should be paid.

Classroom Work.

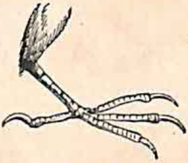
| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| **DUCK.** | | |
| 1. Show a duck's foot. The toes are joined by a thin skin (web-footed). | <br>Fig. 208.—A duck's foot. | **The foot is like a paddle, and is formed for swimming.** |
| 2. Show the picture of a duck. Note that its short, strong legs are placed far back on the body. | Compare with the fish's tail, the frog's legs, the tadpole's tail, &c. | **The position of the legs, though bad for walking, is favourable for swimming.**<br>**The power in each case is placed at the end of the body; hence this is the best position for swimming.** |

## FOWL.

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 1. Show a fowl's foot. Note that the *legs* are strong, and the three front toes are a little joined, and have stout, blunt claws, the hind toe being raised above the level of the others. | Young chicks begin to scratch the ground soon after they are born. Their food consists of grubs, grain, and seed. | **The foot is formed for scratching up the ground.**<br>**The nature of their food shows the necessity for scratching.** |
| 2. Show the foot of the male bird. The toes are short and thick, and the ankle bone bears a spur. The claw on the middle toe is the largest. | <br>FIG. 209.—A hen's foot. | **The spur is used against foes and rivals.** |

## SPARROW.

| Observations and Experiments | Remarks | Inferences |
|---|---|---|
| 1. Show the foot of a sparrow. Note that there are three toes in front and one behind. | In some birds the inner toe may be turned either backwards or forwards.<br>This is the largest class of birds, and includes most of the birds best known to the children. | **They can easily grasp a twig or a branch.** |
| 2. Take a fowl's leg (or the leg of any perching bird), and with a razor or a sharp knife cut through the skin at the ankle joint. Break the joint with the blade of a penknife, and the tendon will be seen. Give it a sharp pull, and it will break where it commences on the muscle of the thigh; then draw it out, hold the foot with one hand, and pull the tendon with the other; the toes close as if grasping. | This tendon and muscle arrangement is made for perching. Near the surface on the *front part of the thigh* there is a slender little *muscle*, which starts from the *front of the lower part of the body, passes down the front of the thigh, winds round to the back of the knee, and then runs by a tendon into a muscle used for bending the longest toe.* This is at the back part of the leg, and is kept in its place by a *muscular ring*. It then passes down behind the leg bone, and finds its way through another *muscular ring*, and so finds its way along the back of the ankle bone to where the toes join, where it divides and runs as *little cords* under the toes. | **When the bird sits down (perches) its joints are bent by the weight of its body; the cord or tendon is stretched or pulled, and the toes are made to grasp.** |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. Examine the legs and contrast them with the size and weight of the body. Note that the legs are slender, the toes are slender and easily bent, and of moderate length. | They spend most of their lives hopping and perching on the twigs and branches of trees. | **The legs seem too weak to support the body; hence these birds cannot run, they can only hop and perch** |
| 4. Note also that the claws are long, slender, pointed, sharp, and slightly curved. |  FIG. 210.—A percher's foot. | **The claws are formed to assist the perching habits of these birds.** |
| 5. Birds of this class sleep perching. | | **The bird cannot fall, for the very act of perching makes its toes clasp the branch.** |

## THE FEET OF BIRDS (SECOND LESSON).

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **OWL.** | | |
| 1. Show the foot and leg of an owl, and note that its *legs* are short, stout, and strong. | Or sketch on B.B. fig. 211. | **The strong legs are necessary both for attacking its prey and for defence. If attacked the owl flings itself on its back and kicks so fiercely as to beat off any ordinary foe.** |
| 2. Examine the *toes*. There are four; three before and one behind. Note the strong, curved, and sharply pointed claws. | The owl can push forward or draw back its claws like the cat. They are splendid mousers—better than cats. | **The claws are suited to the capture of prey and for defence.** |
| 3. Show that the outer toe can be turned either backwards or forwards. | | **The foot thus becomes like a hand for grasping or climbing.** |
| 4. Note that the feet are feathered in the form of hairs. | | **A night bird; hence warm protection even for feet.** |

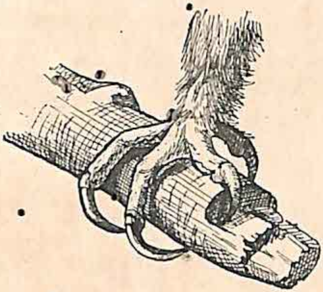


FIG. 211.—The foot of an owl.

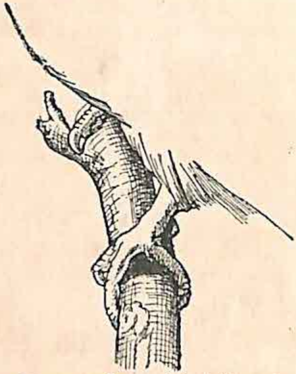


FIG. 212.—Leg and foot of parrot.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 5. The owl is a bird of prey. It feeds on other animals. | Small prey is swallowed whole, but larger prey is first torn with the claws and beak. | |
| **PARROT.** | | |
| 1. Show the leg and foot of the parrot; the *leg* is short and strong-looking. | Or sketch on B.B. fig. 212. | **Its short strong legs are adapted to climbing.** |
| 2. Look at the *toes*; there are four; two in front and two behind. Of the two turned backwards one is the proper hind toe, and the other is the outside toe of the three usually turned to the front. | | **The arrangement of the toes and the ease with which the claws are bent show the foot to be specially adapted for grasping and climbing, for the foot becomes like a hand.** |
| 3. Examine its *claws* and note that they are easily bent. | | |
| 4. The two front toes are joined at their bases by a skin; the other two being free. | | **This skin strengthens the toes.** |
| 5. The parrot is rarely seen on the ground. | Its food consists of fruits and honey.<br>It is rarely seen on the ground because its feet are not suited for walking or hopping, and its legs are not long enough for wading. It could only hobble on the ground. | **The nature of its food makes climbing a necessity.** |

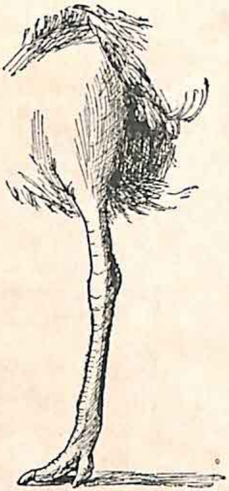


FIG 213.—Leg and foot of the ostrich.

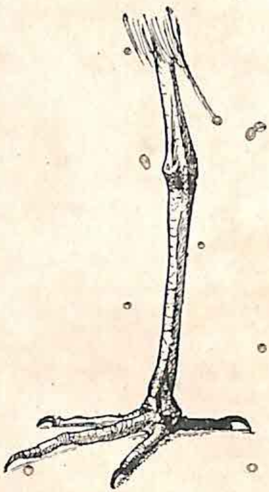


FIG. 214.—Leg and foot of the heron.

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| **OSTRICH.** | | |
| 1. Show the picture of the ostrich, and call attention to its long, strong-looking legs. Note that the *thighs* are naked, but that the *legs* are covered with scales (fig. 213). | The sinews of the legs are remarkably strong. Those which run to the heel feel like bendable horn to the touch. It can run faster than a horse.<br>Compare with other animals famous for their running powers, like the horse, dog, spider, &c., they all have good leg power. | The leg and foot is built for running and kicking. To escape from its enemies it has to dedepend entirely on its legs. It runs from its foes in a circular course. Its kick is simply terrific.<br>Naked thighs and scaly legs are both favourable to running, a minimum resistance being offered to the air. |
| 2. Note that there are only two toes, the third one being missing. Note also that the outer of the two toes is without a claw, but the other toe, which is the larger, is armed with a sharp, powerful claw. | | More than two toes are not required, as they never perch.<br>The sharp, powerful claw is used for defence.<br>[Compare with the brown owl.] |

| OBSERVATIONS AND EXPERIMENTS | REMARKS | INFERENCES |
|---|---|---|
| 3. Note its large, broad *feet*. | Its home is in Africa. | **Suited to the sandy tracts of Africa.** |
| 4. Its food consists of seeds, grain, fruits, insects, and small animals. It also swallows pieces of iron, glass, large stones, &c. | Compare with fowl. | **No teeth; hence stones, &c., swallowed to grind up the food.** |

**HERON.**

| | | |
|---|---|---|
| 1. Show a picture of the heron, and note its very long legs. They are slender but strong. | See fig. 214. | **The heron is a wader; hence long legs are necessary.** |
| 2. Examine the feet. Note that the toes are spread. | | **This enables them to tread lightly over soft mud and the leaves of floating plants.** |
| 3. An examination of the *middle claws* of each foot would show a number of small, horny projections, very much like the teeth of a comb. | The use of these is not at present known. | **From what was learned of the heron in the last lesson it might again be elicited that long legs, long necks, and long bills often go together.** |
| 4. Note that the toes are not completely webbed, and they are very long and straight. Three toes are turned forward. Sometimes the fourth is missing, and, if present, it is always very short. | Contrast with duck. | **These birds are not swimmers, and therefore a completely webbed foot is not required.** |

*Summing up*, we infer that **the shapes and arrangements of the toes vary with the habits of the birds.**

Drawing and composition to follow.

PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
LONDON